EnALI: A Research and Design Framework for Virtual Characters and Pedagogical Agents

George Veletsianos, Charles Miller, & Aaron Doering

Abstract

Conflicts occur when learners interact with pedagogical agents and virtual characters. Such conflicts – arising from technological limitations, psychosocial perceptions, and pedagogical inadequacies – hinder communication and interaction between virtual characters and learners, and impede successful engagement with learning tasks and experiences. To enhance communication and interaction between virtual characters and learners, we propose a three tier framework of fifteen research-based guidelines. This framework enables theorists, researchers, and designers to view virtual characters with a holistic lens, informing the analysis, design, development, implementation, and evaluation of virtual characters in electronic learning contexts.

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Researcher: So, how do you feel about her?

Chad [Student]: I *hated* Joan, or whatever the super-agent lady was called. She asked me at one point 'Are you testing me?' like we were going to have some sort of a confrontation. I've never wanted to hurt a digital person before!

Of Humans and Machines

The use of machines to enhance human life is not a foreign concept. Since the beginning of humankind, we have used tools and machines to improve our way of life. Early humans used rocks and wooden sticks to hunt more efficiently. Automobiles allowed us to travel long distances effectively. Cell phones enable us to remain connected to others regardless of our physical location. Yet, the interactions between machines and humans are not always harmonious. Can you recall an instance when your word processing application was not "listening" to you – not doing what it was "supposed" to do? Remember the time when your cell phone reception wasn't allowing you to place an important call? Or, the time when your teapot kept whistling – some might say yelling – that you remove it from the stove? The annoyances and shortcomings of machines (and modern technology in general) are plentiful and well documented (Norman, 2007).

Smooth interaction and communication between users and machines are neither ordinary nor common. When humans communicate with their machines (e.g., their cars), the "dialogue" between humans and machines is often cumbersome and unidirectional. Humans and machines do not "converse" smoothly – rather, humans make choices out of the options relayed to them by

their machines (Norman, 2007). Returning to our teapot example, do you ask your teapot to wait when it starts whistling? Or do you attend to its calling? The fact that communication between humans and machines is not smooth in varied and everyday aspects of life heightens the importance of this problem. Insights gained from an investigation of this issue may be valuable to researchers and practitioners in numerous domains including design, engineering, human-computer interaction, computer science, communication studies, new media studies, and education.

<div style="text-align:center">The Use of Virtual Characters in Education</div>

Awkward and cumbersome interactions between humans and machines are also prevalent in educational settings – especially in technology-mediated education. More specifically, smooth, natural, and effective communication is the exception rather than the norm in the interactions between learners and virtual characters. Such characters have been termed pedagogical agents and can be defined as human-like personas employed in electronic learning environments to serve various instructional goals (Baylor, 2002). In this manuscript, we will use the terms virtual character, pedagogical agent, and agent interchangeably to refer to such personas.

Even though advances in hardware and software have enabled the use of pedagogical agents in educational circles, conflicts arise when students hold real-time interactions with pedagogical agents. Most notably, learners become frustrated with pedagogical agents and frequently express feelings of frustration, anger, mistrust, and apprehension when they interact with them (Authors, 2007, 2008a, 2008b). Such feelings hinder communication and interaction between virtual characters and users, and impede successful engagement with learning tasks and experiences. Chad's quote highlighted in the beginning of this paper exemplifies this point. More

importantly, Chad's experiences are not unique. The examination of the pedagogical agent literature, to which we turn our attention shortly, especially in the context of conversational pedagogical agents, indicates that such experiences are pervasive (Authors, 2007, 2008a, 2008b; Clark & Mayer, 2007; Shneiderman & Plaisant, 2004).

It is imperative to note that given various tendencies in online education, e-learning, and technology-mediated education in general, the assimilation of virtual characters in electronic learning environments is expected to continue and flourish (Federation of American Scientists, 2006), making the topic of agent-human interactions even more significant. For example, in virtual three-dimensional worlds, such as Second Life, users interact via virtual characters (avatars). As hundreds of educational institutions have established a presence in Second Life and have started using this environment as a teaching tool (Jennings and Collins, 2008), the issue of enhanced interaction and communication between humans and virtual characters becomes more pressing.

As more and more learners ~~engage~~ participate in electronic learning experiences ~~mediated by~~ where virtual characters ~~beings~~ are also present, we must understand how to effectively design such characters for teaching and learning, fostering effective interaction between humans and agents – an endeavor that numerous researchers (e.g., Authors 2007, 2008; Federation of American Scientists, 2006; Van Vuuren, 2007) consider important, challenging, and, as of yet, unaccomplished. Therefore, in this paper, we provide a theoretical lens through which agents and media can be perceived, present a review of pedagogical agents and their interactional inadequacies, explain the conflicts that arise when learners interact with pedagogical agents, and provide a framework to reflect upon and guide the design of effective agent-learner interactions. To the best of our knowledge, this framework is one of few instances

of a well-rounded approach to the design of pedagogical agents' interactional capabilities[1] (another example can be found in Kim & Baylor, 2008). We conclude by offering suggestions for future research directions to utilize the proposed framework and improve research on pedagogical agents.

The Social Nature of Media

One of the fundamental theoretical arguments used to support the integration of pedagogical agents in education is that virtual counterparts can enact socio-cultural aspects of learning (Vygotsky, 1978), in effect enhancing social interactions between learners, teachers, and computers (Gulz, 2004; Kim & Baylor, 2006). In other words, previous work suggests that social interaction between learners and virtual characters may enhance learning, especially due to the fact that pedagogical agents are perceived to be social models (Kim & Baylor, 2007). The human-computer interaction field has gone a step further, proposing that humans respond to media in general, and virtual characters in particular, in inherently social ways (Reeves & Nass, 1996) - an observation termed "the media equation." This hypothesis has been supported by overwhelming experimental evidence (Reeves & Nass, 1996), while, in the context of pedagogical agents, it has been observed both phenomenologically (Authors, 2008c) and longitudinally (Authors, 2008a).

The implication arising from these results is powerful: If humans treat computers and media as if they are human, interaction between humans and computers is expected to approximate social interaction between humans and humans. Holtgraves, Ross, Weywadt, and Han (2007) provide support for such a hypothesis by presenting evidence indicating that participants viewed conversational software systems as encompassing human-like personalities

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[1] A "well-rounded" approach to the design of agents refers to design approaches that are holistic and are concerned with enhancing multiple facets of pedagogical agents rather than simply manipulating one variable.

and characteristics. For example, a character who responded quickly to users was perceived to be more conscientious and extraverted than a character who did not respond as quickly, leading the authors to argue that, "perceptions of the bot [virtual character] were influenced by communication variables that have been demonstrated to influence perceptions of human communicators" (p. 2172). Louwerse, Graesser, Lu, and Mitchell (2005) also present evidence indicating that learners perceive pedagogical agents to ascribe to human characteristics. These findings further imply that humans expect their interactions with media and conversational systems to abide by human norms. To this effect, one approach we can take to enhance the interaction between virtual characters and learners is to investigate the communication variables that influence perceptions of human communicators and extend such variables to the design of virtual characters. If humans perceive virtual characters as human counterparts, then variables that influence the ways humans perceive others are likely to influence our perceptions of virtual characters. Prior to identifying such variables, we must first identify and examine the issues that arise when agents interact with learners.

A Review of Pedagogical Agents and their Interactional Inadequacies

The pedagogical agent and virtual character literature spans multiple disciplines. For instance, research on mediating virtual characters has been carried out in the instructional design (e.g., Baylor, 2002), human-computer interaction (e.g., Gulz & Haake, 2006a), engineering (e.g., Paiva & Machado, 2002), and communications (e.g., Yee, Bailenson, Urbanek, Chang, & Merget, 2006) fields. Additionally, pedagogical agents have been utilized in diverse content areas including economics (Baylor & Ryu, 2003), nanotechnology (Hershey-Dirkin, Mishra, & Altermatt, 2005), computer literacy (Graesser et al., 1999), and geography (Authors, 2007). To

gain an encompassing view of virtual character use in education we review literature from multiple disciplines.

Researchers have touted the benefits that pedagogical agents can bring to learning contexts (Baylor, 1999, 2000; Payr, 2003). For instance, pedagogical agents can model behaviors and act as role-models (Rosenberg-Kima et al, 2008), demonstrate complex tasks (Johnson et al, 1998), personalize the learning experience (Gulz, 2004), and motivate the learner (Johnson, Rickel, & Lester, 2000). Yet, evidence regarding such benefits has been mixed (Clark & Choi, 2005; Gulz, 2004) and it has been observed that when learners interact with pedagogical agents, interaction between the two parties, as evidenced by Chad's comment in the beginning of this paper, is cumbersome and, at times, awkward (Authors, 2008b). Such problematic communication impedes successful engagement with educational tasks, contributes to poor learning experiences, and ultimately obstructs learning.

How is agent-learner interaction ineffective? How is communication between agents and learners unwieldy? Agents frustrate learners due to their inability to respond positively to requests for assistance. Consider two types of agents: The passive one that presents information to a learner on a particular task (e.g., Baylor, 2002), and the conversational one where students have the option to ask the agent questions (e.g., Graesser et al, 1999). The first type of agent acts as a delivery mechanism (c.f. Clark, 1983; e.g., Choi & Clark , 2006): Such a tool merely delivers a linear flow of information that fails to consider the learner while he/she engages with a task. If the learner has questions, concerns, or any other kinds of requests regarding the task, the agent is simply unable to dynamically respond. The second type of agent is reactive and responsive. This agent may respond to learners' questions or comments. Conversational agents appear to solve the problem presented by passive agents, but a second, perhaps equally important

issue arises: Technological limitations have prevented researchers and scientists from developing truly intelligent agents that are able to "listen," "perceive," and "anticipate" user actions (van Vuuren, 2007). Even if scientists were able to develop systems that enable learners and agents to converse smoothly, it would still be difficult to hold meaningful conversations with machines. As Norman (2007, p. 9) argues, "successful dialogue requires shared knowledge and experiences… It is hard enough to establish this shared, common understanding with people, so how do we expect to be able to develop it with machines?" As a result, pedagogical agents able to hold conversations with learners often fall short of learner expectations and are unable to provide meaningful answers to meaningful questions, frequently leading to negative emotions such as frustration, anger, disappointment, etc (Authors, 2008a).

Conversational agents present a second and rather surprising problem: Learners become mesmerized by such agents and often lose their sense of time (Authors, 2008c). We call this a surprising problem because in education we usually go at great lengths to immerse students in learning experiences. Yet, in this instance where learners are indeed immersed, rather than being engaged with the task, they are engaged with the technology. In essence, pedagogical agent deployments seem to suffer from the extremes –either being unhelpful and therefore non-engaging, or being ~~too engaging~~ immersive, misdirecting attention from the task. Indeed, even if conversational agents may not necessarily be able to respond correctly to requests for learner assistance, their ability to have a conversation bewilders learners (ibid), leading them to focus more on socially interacting with the agent than working towards solving a task. Although researchers may be able to exploit such immersive experiences for learning purposes, a fine line exists between students being engaged and being immersed to the point of losing focus of the task.

One reason that learners may be drawn in the conversation with a pedagogical agent is due to the latter's representation. Anthropomorphism – the portrayal of non-human life forms as humans – may elicit heightened expectations from learners (Norman, 1997). For example, due to agents being portrayed as having human abilities, learners may be driven to question the agent and intimately explore the technology's "intellectual" powers and inadequacies. However, agents, as described earlier, are not yet intelligent and portraying them as humans encourages learners to ascribe intelligence to them. Inevitably, learners come to expect agents to respond in a human-like fashion with certain naturalness, grace, and perhaps intellect (ibid ~~Norman, 1997~~). Disappointment and disenchantment ensues when agents fail to respond to learners in the way they were supposed to.

Finally, it is important to note that the interaction between learners and pedagogical agents appears to be mediated by issues of gender, power, and authority, where agents are often subject to misuse. For example, research has shown that users abuse virtual characters, especially female ones (DeAngeli & Brahnam, 2006). Similar misuse has been observed in the interactions between pedagogical agents and middle school students in the context of a geography lesson (Authors, 2008b). The reasons for such an abuse are not yet well understood. In a recent special issue of the journal *Interacting with Computers* (2008, Volume 20, Issue 3) researchers have attempted to understand and explore the issues of agent abuse and misuse. As a result, a number of themes have emerged with regards to the reasons that humans may misuse virtual characters including perceptions of anonymity, perceptions of agents being inferior to humans, and user experimentation.

A Definition of Problematic Agent-Learner Interactions

The issues that arise when agents and learners interact are varied. To be able to address such issues in a holistic fashion, we define them in terms of *conflicts of interest* using literature from the conflict resolution field.

Conflicts are ubiquitous. From a misunderstanding between colleagues, to an argument between spouses, to an internal struggle, to differing opinions between countries, everyone has, at one point experienced a conflict in their life. This outlook of conflicts is exemplified by Deutsch (1973) who notes that a conflict exists whenever incompatible activities occur. An incompatible activity is one that "prevents, blocks, or interferes with the occurrence or effectiveness" (p. 10) of a second activity. Johnson and Johnson (2006, p. 370-371) extend Deutsch's definition and define an interpersonal conflict as one that exists "when the actions of one person attempting to maximize his or her benefits prevent, block, interfere with, injure or in some way make less effective the actions of another person attempting to maximize his or her benefits." Even though Deutsch and Johnson & Johnson write specifically for activities that occur between individuals, in this paper we have shown that incompatible activities also exist when humans interact with inanimate objects – specifically when learners interact with pedagogical agents. To contextualize the issues that arise when learners interact with pedagogical agents, we define agent-learner incompatible activities as conflicts that exist when the actions of the agent attempting to maximize its benefits prevent, block, interfere with, injure or in some way make less effective the actions of the learner attempting to maximize his or her benefits (e.g., the agent being unresponsive to student requests for assistance). The converse is also true. In other words, conflicts also exist when the actions of the *learner* attempting to maximize his or her benefits prevent, block, interfere with, injure or in some way make less

effective the actions of the *agent* attempting to maximize its benefits (e.g., the learner misusing the agent).

Johnson and Johnson (2006) note that there are two ways to manage conflicts – constructively or destructively. Resolving conflicts constructively leads to numerous beneficial outcomes including strengthening liking, respect, and mutual trust, while resolving conflicts destructively leads to anger, resentment and distrust. It is also important to consider that without training students tend to resolve conflicts destructively (Johnson & Johnson, 2003). The Teaching Students to be Peacemakers (TSP) program, an effective intervention for the constructive resolution of conflicts in school settings (Johnson & Johnson, 2001; 2003), trains students to work cooperatively, negotiate with each other, mediate conflicts, and problem solve in order to reach constructive solutions. At the core of this program, and foundational to the effective mediation of conflicts, lies the understanding that students are able to effectively communicate with each other. Effective communication, defined by Johnson and Johnson (2006, p. 13) as the situation "when the receiver interprets the sender's message in the same way the sender intended it" is paramount for the smooth functioning of group processes.

To summarize, effective communication between individuals appears to be the cornerstone of managing conflicts constructively. Therefore, to resolve agent-learner conflicts, agents and learners need to engage in effective communication. In other words, the driving force behind improving agent-learner interaction is effective communication. In the following sections we present a framework that intends to alleviate agent-learner conflicts and enable learners to engage in smooth, natural, and effective interactions with agents.

<center>Enhancing Agent Learner Interactions: The EnALI Framework</center>

Even though researchers have made attempts to enhance the interactional capabilities of agents, we propose a well-defined, extensive, and multifaceted framework for the design of agents and their interactional potential. This framework is grounded on socio-cultural notions of learning (Vygotsky, 1978), cooperative learning (Johnson, Johnson, & Holubec, 1993), and conflict theory (Deutsch, 1973) – for ease of use we have named this framework *Enhancing Agent Learner Interactions* or EnALI.

So far, researchers have proposed sets of ideas and variables that need to be considered when designing agents. For instance Gulz and Haake (2006a) have noted that visuo-aesthetic aspects of agents are an important consideration in the design of pedagogical agents; Mayer, Johnson, Shaw, and Sandhu (2006) and Johnson, Kole, Shaw, and Pain (2003) argued for socially sensitive computer-based tutors emphasizing agent expressiveness, politeness, and empathy; FAS (2006, p. 9) stated that agents need to exhibit emotions and behave realistically while at the same time portraying "correct exterior design (appearance), … movements, reactions, and decision-making that appear natural, appropriate, and context-sensitive;" and Dehn and van Mulken (2000, p. 19) proposed that we need to reconsider design and research endeavors by asking "what kind of animated agent used, in what kind of domain influences what aspects of the user's attitudes or performance." Other researchers have proposed interesting research directions and pedagogical agent constituents. For example, Kim and Baylor (2006) propose seven research constituents – competency, interaction type, gender, affect, ethnicity, multiplicity, and feedback. Although these variables of interest provide a valuable foundation for furthering empirical research, designers require practical guidelines that are in close alignment with design inquiry and practice. For example, aesthetics may be an important facet of pedagogical agent design (Authors, 2007b), but exactly how should aesthetics be integrated in

the design of virtual characters (Gulz & Haake, 2006a, 2006b, 2006c)? "Correct exterior design" may matter but what does "correct" mean? The same holds true for agent feedback. What kind of feedback should agents give to learners, when, and how often?

Additionally, most of the above investigations and recommendations investigate a variable of interest (e.g., agent gender and ethnicity) and put forth recommendations or guidelines for design. In this paper, we take a different approach by presenting guidelines for design rather than research variables. An important consideration in the development of these guidelines has been the notion of social, pedagogical, and technological affordances of pedagogical agents (c.f., Norman, 1988; Kirschner, Strijbos, Kreijns, & Beers, 2004). In other words, pedagogical agent integration in educational settings should be guided by the added-value opportunities that agents present for enhancing the social, pedagogical, and technological opportunities provided to learners. These guidelines arise from (a) our previous work with pedagogical agents, (b) previous research regarding agent-learner interactions [espousing both learner input (e.g., Haake & Gulz, 2009) and instructor recommendations (e.g., Veletsianos & Miller, 2008)], and (c) previous research in human-human communication (Johnson & Johnson, 2006). We propose the EnALI framework in the belief that it will (a) assist designers in enhancing pedagogical agent deployments, (b) start a conversation in the field as to the ways we can transform the use and effectiveness of pedagogical agents, and (c) allow other researchers to study, critique, revise, expand, and improve this framework.

We have divided the EnALI guidelines into three design foci: user interaction, message, and agent characteristics. *User interaction* refers to the ways the agent and the learner act and work together, cooperate with each other, and relate to each other; *message* refers to the design of comments, feedback, and information the agent sends to the learner; and *agent*

characteristics focuses on those variables that inherently define the agent. These three categories arose naturally after the guidelines were devised and the reason that the guidelines are presented in this way is to assist in designers' use of the framework. Even though we present and describe the guidelines under these discrete categories, it is important to note the interrelated nature of these guidelines. In other words, guidelines may work in conjunction with each other, exhibiting feedback effects. For example, a polite, positive, and expressive agent may be perceived to be more credible than one who exhibits uncooperative behavior. In addition, it is also important to note that guidelines could be placed in more than one focus category. For example, the "being redundant" guideline reflects the way the agent interacts with the learner *and* describes the message delivered to the learner. As such, it can be placed in either the user interaction or the message category.

Table 1 presents the EnALI framework. Each guideline is discussed and explained below.

Table 1: Enhancing Agent Learner Interactions (EnALI) Framework

	Design focus	*Guidelines*
1	User interaction	*Agents should be attentive and sensitive to the learner's needs and wants by:* a. Being responsive and reactive to requests for additional and/or expanded information. b. Being redundant. c. Asking for formative and summative feedback. d. Maintaining an appropriate balance between on- and off-task communications.
2	Message	*Agents should consider intricacies of the message by:* a. Making the message appropriate to the receiver's abilities, experiences, and frame of reference. b. Using congruent verbal and nonverbal messages. c. Clearly owning the message. d. Making messages complete and specific. e. Using descriptive, non-evaluative comments. f. Describing feelings by name, action, or figure of speech.

3	Agent characteristics	*Agents should display socially appropriate demeanor, posture, and representation by:*
		  a. Establishing credibility and trustworthiness
		  b. Establishing role and relationship to user/task.
		  c. Being polite and positive (e.g., encouraging, motivating)
		  d. Being expressive (e.g. exhibiting verbal cues in speech).
		  e. Using a visual representation appropriate to content.

Agents should be attentive and sensitive to the learner's needs and wants

In the context of a lesson and a learning task, would a learner collaborate or interact with someone who is inattentive and insensitive to his/her learning needs, with someone who is of minimal help and assistance? Would s/he seek assistance from such a technological tool? Or, would s/he simply ignore whatever assistance the agent may have to offer? Simply put, when the agent supports and scaffolds the learner, such assistance is both valuable and valued. To achieve attentiveness and sensitivity, we recommend that agents abide to the four guiding principles that follow.

Agents should be responsive and reactive to requests for additional and/or expanded information. In human-human interactions, participants are both information recipients and conveyors. In educational settings especially, educators have attempted to move away from the banking model of education where teachers treat students as bank accounts waiting to be filled, where empty and passive brains are waiting to be crammed with information (Freire, 1970). In an era where critical thinking and problem-solving skills are deeply cherished (Jonassen, 1995; 2000), where collaboration and creativity are valued, why are most pedagogical agents designed as passive tools that deliver pre-recorded information, as new iterations of the *media debate* (Choi & Clark, 2006; Clark, 1983)? Why are agents designed as tools whose sole purpose is to deliver information to learners? If pedagogical agents are to become useful counterparts in the

learning experience they need to be both *responsive* and *reactive*. Responsiveness refers to the agent's ability to act to learners, events, or environmental stimuli, while being reactive refers to the ability of the agent to respond to learner requests. For instance, when a learner asks the agent to define the term *seismic activity* the agent should be able to do so. Care should be taken, however, to avoid highly scripted interactions that force the learner into pre-determined paths or immersive interactions that deviate extraordinarily from the learner's task (further information on the latter point is provided under the guideline entitled *Agents should maintain an appropriate balance between on- and off-task communications).* Alternatively, if the learner is engaged with a task that is unrelated to the agent, the agent should withdraw, enabling the learner to focus on what he/she deems to be important or necessary at the time.

     Agents should be redundant. Redundancy refers to the duplication and repetition of information and often comes with a negative connotation. In effective communication however, redundancy enables information recipients to clearly understand a message. Redundancy, in effective communication, implies (a) sending the same message - often paraphrased - more than once and (b) conveying the same message using more than one channel of communication (often referred to as redundant subtexts). For example, when one person is attempting to explain to another why he felt cheated while they were playing chess, he could use a chess board to re-enact the conflict of interest. The same guideline extends to the interaction between pedagogical agents and learners. In other words, pedagogical agents should be redundant, sending the same message more than once and utilizing more than one channel of communication to interact with learners. For example, agents can utilize a database of imagery, video, and explanatory graphics to augment their interaction with the learner, conveying the same message using multiple modes of interaction and advancing the explanatory power of the information being presented. One

example of a research study that investigated this guideline is Moreno and Mayer' (2002) study. In the context of multimedia learning the authors argue that verbal redundancy refers to "the simultaneous presentation of text and narration with identical words" (p. 156) enabling learners to learn more when the verbal channel reinforces the auditory channel and vice versa.

Agents should ask for formative and summative feedback. In conflict resolution negotiations participants should ask for feedback of how the receiver perceives, understands, and interprets their messages (Johnson & Johnson, 2006). Feedback can facilitate a conversation because misunderstandings can be prevented and resolved. In the same way, pedagogical agents can ask for formative and summative feedback from learners. Formative feedback can assist the agent to evaluate how the learner is progressing on a given task or lesson, while summative feedback can assist designers in evaluating the completed interaction between the agent and the learner. Such feedback can serve two purposes: First, the system can log learner responses and designers can modify agent properties according to such feedback. Second, the agent can adapt his/her response according to the learner's response. Norman (2007) exemplifies the importance of feedback,

> Without feedback, we can't operate, whether it is with an elevator, a person, or a smart machine... Actually, feedback is probably even more essential when we interact with our machines than with other people. We need to know what it is happening, what the machine has detected, what its state is, what action it is about to do (p. 139).

The challenge with this guideline lies on the fact that technological solutions need to evolve beyond the pattern and keyword-matching approach and scripted response algorithms to sophisticated evolutionary models of interaction where meaningful agent actions and responses

are formed dynamically and intuitively (van Vuuren, 2007). Researchers have expressed their dissatisfaction with the current state of artificial intelligence systems used for educational purposes (Authors, 2008a; Gulz, 2004) and noted the difficulties of exploring advanced conversational techniques in student-agent interactions. Nevertheless, designers and researchers, at times, need to focus on elements beyond the constraints of the technology so as to push our field forward in designing and researching powerful learning experiences. If our sole focus is on what is possible with current technology, we are limiting ourselves to truly think creatively about the problems facing our field. Finally, it is important to note that *feedback* here is discussed in terms of agents soliciting information from learners. The idea of pedagogical agents providing feedback *to* learners in terms of their performance is beyond the scope of this framework – interested readers are directed to Kim and Baylor (2006).

Agents should maintain an appropriate balance between on- and off-task communications. Think about a teacher in a 45-minute lesson. Is s/he *completely* focused on the task without deviating *at all* from the lesson's goals and objectives? Does s/he engage in small talk? Is s/he *entirely* focused on matters *outside* of the lesson, discussing football instead of course content? Or is s/he holding a balance between being on-task and off-task? Classroom interactions are not completely focused on the day's lesson. Why, then, are most agents designed to focus exclusively on a task and avoid any deviation from it? A constant delivery of information overbears students' cognitive load, interfering with their ability to focus and process a lecture's content. Additionally, completely focusing on a task may be tiring, while short-term interruptions might allow learners the chance to refocus and recuperate. Maintaining an appropriate balance between the task and matters that are off-task, then, means that the agent should consider the lesson as well as other factors that are unrelated to the task. For instance, the

agent may greet learners, engage in small talk, welcome them back after an interruption, or even hold a short conversation about a popular or contemporary topic.

Agents should consider the intricacies of their message

Messages sent from one person to another are not simple. We may think that the exchange of information is a simple and easy task, but this is merely because we are accustomed to communicating with others (Johnson, 1974). Messages are complex. For instance, messages may account for unspoken rules (e.g., etiquette), contain information unrelated to the task at hand, and encompass rhetorical figures such as metaphors and similes. Such intricacies need to be considered and evaluated if our goal is to attain natural and smooth interactions between learners and agents. Six guidelines to ensure that agents consider the intricacies of their message are described below.

Agents should make the message appropriate to the receiver's abilities, experiences, and frame of reference. Each learner is unique and each learner's abilities, experiences, expertise, and frame of reference are different. In the same way that teachers would explain relativity theory differently to 3rd graders than to college sophomores, pedagogical agents should adjust their teaching practices depending on the learner's background information. It is important to note that differences between learners may be determined prior to the learner engaging with a task (e.g., cognitive ability), or may arise while the learner interacts with the pedagogical agent (e.g., on a given day, the learner may be tired). For instance, the learner's language skills might be below average, and the agent may need to explain items in a different language or use more examples than otherwise. Additionally, previous research has shown that experts perceive, organize, and retrieve information differently than novices (Bransford, Brown, & Cocking, 1999), and this information should be taken into consideration when pedagogical agents interact

with students. Indeed, effective communication between agents and learners requires "common ground" just like effective interpersonal communication requires two people to "be on the same page." Norman (2007, p. 50) further argues that "the lack of common ground is the major cause of our inability to communicate with machines." Yet, designers can experiment with ingenious ways of establishing a common ground between learners and agents. A simple way to do so involves a semi-informal dialogue or testing session at the beginning of a task which can inform the agent to better understand the learner and his/her characteristics, abilities, and experiences. For example, Corbalan, Kester and van Merriënboer (2006) describe an adaptive learning system able to differentiate, adapt, and individualize instruction based on numerous learner characteristics including prior knowledge and cognitive load. Such a system could be utilized in support of a pedagogical agent, scaffolding learners during learning.

Agents should use congruent verbal and nonverbal messages. When humans communicate with each other, their interaction is mediated by both verbal and non-verbal messages. Frequently, these messages are congruent – verbal messages match nonverbal messages. For example, a simple "Hello" accompanied by a smile indicates the greeter's positive emotions. On the contrary, when someone exclaims "Hello," and follows the greeting with a sneer, the meaning of the verbal information might change due to the co-existence of contradictory messages. To avoid misunderstanding between individuals, researchers advise that verbal and nonverbal messages be congruent (Johnson and Johnson, 2006). In other words, verbal messages should match non-verbal messages. This guideline is especially important when agents interact with learners as it implies that the agent's verbal responses should match its nonverbal messages. Although the importance of expressing affect and emotion has been recognized in the pedagogical agent literature (e.g., Kim & Baylor, 2006), to the best of our

knowledge, congruency in verbal and nonverbal messages has not been discussed in prior work. We believe that verbal and nonverbal message congruency has not been utilized because (a) most pedagogical agent deployments use a neutral text-to-speech computer generated voice that lacks voice inflection making verbal messages flat, and (b) facial morphing techniques are still at an experimental level (e.g., iCAT, 2008).

Agents should clearly own their message. Conflict resolution training requires participants to take ownership and responsibility of their statements (Johnson & Johnson, 2006) such that they face personal accountability for their words (Johnson, Johnson, & Holubec, 1993). Ownership can be gained by using first personal pronouns such as "I" and "my." Using abstract phrases (e.g., "some people believe that" or "most people note that") may indicate a refusal to acknowledge ownership and responsibility of a comment. Such comments appear too generalized, without indicating to the receiver the source of such messages. Applying this guideline to pedagogical agent message design implies that the agent should establish ownership of the message and take responsibility for the response. In other words, the agent needs to be clear that he/she is the source of his/her comments. The guideline becomes especially important when considering the credibility and trustworthiness of the agent as message ownership heightens the credibility of the message (also see the guideline on *credibility and trustworthiness*).

Agents should make messages complete and specific. When people communicate about ideas, feelings, and opinions, they should use statements that are clear and inclusive of all necessary information needed by the receiver to understand what the sender is trying to communicate. Completeness and specificity are important but when we communicate with others we usually do not indicate our frame of reference, assumptions, or the leap of thinking we are

making. For effective communication to take place, our statements should be expansive and, ideally, should include what we otherwise would have failed to state. When agents interact with learners, this guideline implies that the agent should give specific and complete responses. Such responses should (a) encompass the frame of reference from the agent's point of view, and (b) be specific in the sense that they should not be plagued with assumptions about the learner or about his/her knowledge (also see the guideline stating that *agents should make the message appropriate to the receiver's abilities, experiences, and frame of reference*).

Agents should use descriptive, non-evaluative comments. When individuals are attempting to negotiate and resolve conflicts it is important that their comments are descriptive rather than evaluative (Johnson & Johnson, 2006). For example, it would be preferable for a student to say "You stood in front of me in line" rather than saying "You self-centered person. You took my place in line." In the same way, pedagogical agents should make descriptive rather than evaluative comments. Even though previous research has already shown the extent of learner frustration when pedagogical agents responded with evaluative comments (e.g., Authors, 2008b), it is logical to assume that evaluative rather than descriptive comments will elicit strong and negative responses from learners. For example, consider the case were a learner spends 10 minutes on a module and only scores 8/20. The agent can give the following descriptive feedback: "You have spent 10 minutes on this module. You can still increase your score." An evaluative feedback would sound more judgmental and could be similar to the following: "You have only spent 10 minutes on this module. You can still increase your score if you pay more attention to this task." Evaluative comments should be avoided, especially if agents are to be sensitive to and appreciative of learners' efforts.

Agents should describe feelings by name, action, or figure of speech. Johnson and Johnson (2006) note that it is important that when people attempt to resolve conflicts, descriptions of feelings should be clear and unambiguous, thereby avoiding misunderstandings. To this end, they suggest that feelings could be described by name (e.g., I am happy), action (e.g., I feel like smiling) or by figure of thing (e.g., I am flying with joy). In the same way, we recommend that agents should be descriptive about their "feelings" when interacting with learners. For example, agents can congratulate learners when they complete a task by unambiguously stating, "I am happy that you completed the module on nuclear thermodynamics." Furthermore, clear and unambiguous expression of feelings is also considered to be an important *emotional skill* in the emotional intelligence literature (W.T. Grant Consortium, 1992).

Agents should display socially appropriate demeanor, posture, and representation

In addition to the design of an agent's attentiveness to learner needs and appropriate construction of messages aligned with learner experience, the visual representation of the agent may, in some circumstances, supersede the former guidelines as learners are initially more sensitive to the visceral (i.e. automatic affective response to appearance) and behavioral (i.e. sub-conscious responses to pleasure and effectiveness of use) facets of an agent's design (Norman, 2004; Authors, 2007b). Therefore, we suggest an equilibrium of design considerations between the critical conceptualization of desired pedagogical outcomes in agent design (Baylor, 2005) and the visual-social semiotics of agent-learner communication. Visual-social semiotics is a field of study grounded in the investigation of what can be done with images and visual means of communication and how these actions are interpreted (Jewitt & Oyama, 2001). In other words, the visual representation of a means for communication (i.e. an agent) can be interpreted in many

ways by learners before any meaningful interaction takes place, influencing the desired outcomes of the agent design. To this effect, we offer the following five principles for agent demeanor, posture, and representation.

Agents should establish credibility and trustworthiness. Powerful affective responses derived from a learner's existing cognitive constructs are often what "make or break" a learner's perception of a virtual environment. An exemplar of this concept is a learner's perceived trust in an agent. When the agent acts as the learner expects, answering questions with haste and providing adequate information to guide the learner forward, trust is high and the result is satisfaction or pleasure with the agent, likely promoting future use and interaction. However, when an agent contradicts the expectations inherent in a learner's cognitive construct, trust is low and the learner experiences negative affect (Norman, 2004). This can cause frustration, irritation, and dissatisfaction, harming the relationship between the agent and the learner. From a design perspective, a central facet of credibility and trustworthiness is the learner's perception of the agent's *seriousness*. In their research examining the visual design of virtual pedagogical agents, Gulz and Haake (2006b) found that several learners believed agents represented by a more realistic human image, as opposed to designs with abstract or cartoon-like qualities, were advantageous in that they felt more *serious* about the task at hand. Ultimately, trustworthiness can be achieved through a balance of efficiency in providing the information and answers that learners are expecting, paired with the agent's visual design representative of what the learner expects in the context of the learning environment. The latter is discussed in the following principle.

Agents should establish their role and relationship to user/task. The perceived role of an agent in relationship to both the learner and the task at hand is an important characteristic of

agent design (Baylor, 2005; Payr, 2003). Learners often enter an online instructional

environment with perceptions and expectations of what the design will provide based on their

needs. This is particularly evident in the preconceived stereotypes learners bring to the

instructional context. If the visual representation of the agent is uncharacteristic of the

instructional content, learning may be hindered. For instance, agents may be designed to act as

co-learners, whereas learners may perceive them to be content experts. Author (2007b, p. 374)

defines agents that conform to the content area under which they function "contextually

relevant" and draws attention to this point by arguing that, "contextual relevance is important

because it may influence learners' attention and perceptions and degree of agent relevance,

seriousness, and authenticity." Baylor (2005) found that providing a choice of agents (i.e.

allowing learners to select the visual design of their agent) and using non-stereotypical

representations may be beneficial for learners. Moreover, once the agent's role in the context of

learning is established, the learner must perceive the agent as *useful* if any meaningful

interactions are to occur. Usefulness can be defined in terms of a design's usability and utility

(Kirschner, Strijbos, Kreijns, & Beers, 2004). Whereas usability is concerned with the

effectiveness, efficiency, and satisfaction with which learners can accomplish a set of tasks,

utility is defined as the array of functionalities and features incorporated by a design (i.e. does

the design satisfy the pedagogical needs of the learner?). An agent that is usable but does not

provide users with the information they need to accomplish their learning goals is of little value.

Similarly, an agent infused with an assortment of valuable information but is difficult to use will

lead to dissatisfied learners. Therefore, designers must ensure that agents establish their

relationship within the context of the learning space by providing the information and tools that

learners need to accomplish their tasks in an efficient and effective manner.

Agents should be polite and positive (e.g., encouraging, motivating). In addition to establishing credibility and a direct relationship with the task at hand, agents should be designed to communicate in a polite and positive manner, encouraging and motivating the learner throughout the learning process. Research suggests that when we exhibit positive emotions such as happiness, pleasure, and satisfaction (Jordan, 2000), we experience enhanced curiosity, creativity, and decision-making skills, ultimately broadening our thought processes and promoting activities directly related to learning (Ashby, Isen, & Turken, 1999; Norman, 2004). Therefore, an agent that communicates with learners through a positive and motivating demeanor, when contrasted with dry, insensible interaction, has the potential to connect with learners on a deepened emotional level, consequently encouraging learners to think more creatively and resourcefully when interacting with agents or when solving an educational task. Although the literature on polite pedagogical agents is still at its infancy, Wang et al. (2008) found that a polite version of pedagogical agents enabled learners to learn more than a version of a pedagogical agent that was not as polite. Most importantly, designers must focus on the experience of the learner when interacting with the agent. In essence, an agent that is negative, discouraging, or even comatose in demeanor, will be perceived in a more negative light than an agent that is polite and positive, hindering learning and successful engagement with a task.

Agents should be expressive (e.g., exhibiting verbal cues in speech). Imagine a good presentation, lecture, or lesson. Can you visualize the way the speaker expresses herself? Is she expressive and enthusiastic? Or is she monotonous and flat? Experienced speakers and teachers know that being monotonous is not the way to command an audience's attention. Why, then, are most agents designed to deliver dispassionate lectures? Monotonous soliloquies that lack expressiveness interfere with students' attempts to focus on a lesson, incite negative impressions

of the agents, and hinder effective learning. Importantly, expressiveness can be defined on multiple communication channels. Expressiveness includes verbal and non-verbal modes of interaction including subtle intricacies such as facial cues and nuanced linguistic variables such as word emphasis, intonation, and inflection. Epleya and Krugerb (2005, p. 415) highlight this attribute by noting that "paralinguistic cues such as gesture, inflection, pronunciation, vocal expression, fluency, and tone are each important clues to a speaker's meaning – and personality."

Agents should use a visual representation appropriate to content. Parallel to an established relationship with the user and task, the visual representation of the agent should be appropriate to both the learner and the contextual and physical (or, in this case, virtual) attributes of the environment. Gulz and Haake (2006b) define the visual representation of an agent "in terms of its body and face shape, gender, ethnicity, age, clothes, and attributes – as well as in terms of the graphical style and the degree of visual naturalism with which it is represented" (p.1849). These attributes are categorized as *static qualities*. *Dynamic qualities* include the representation of gestures, movements, facial expressions, and gaze. Further, Gulz and Haake (2006c) suggest two dichotomous comparisons of agent graphical style: naturalism vs. stylization and detailed vs. simplified. The naturalism vs. stylization dichotomy refers to the degree with which the graphic design of an agent is representative of a realistic human image (i.e. naturalism) or is based on more abstract or cartoon-like qualities (i.e. stylization). The detailed vs. simplified dichotomy, on the other hand, refers to the dimensions of visual design taken to illustrate characteristic features in the graphical representation. Detailed styles focus on representing the majority of realistic nuances in the static qualities of the agent, whereas simplified styles focus on visual representation from a minimalist perspective (i.e. the design is stripped down to its fundamental features). With concern to these important variances in graphic representation, we

recommend that the visual design of an agent must take into consideration four critical factors: (1) the nature of the content, (2) the context of learning, (3) the demographics of the learner audience, and (4) the inherent design of the agent's surrounding virtual environment. For example, an agent represented by a rockstar-styled character may not be a suitable fit for an 10th grade online chemistry course, just as a chemist-style agent design may not be appropriate for a 3rd grade online music education course (Authors, 2006; 2008c).

Future Directions

In this paper, we discussed the use of virtual characters in education and the shortcomings that arise when pedagogical agents interact with learners. Additionally, we have defined interactional shortcomings as conflicts of interest, and argued that agent-learner interaction, and therefore learning, could be enhanced if we rethink the communication between learners and agents in the context of the conflict resolution literature. To this end, we presented and explained the EnALI framework consisting of fifteen guidelines aimed at enhancing agent-learner interaction, minimizing learner frustration, and enhancing learning.

Although the EnALI framework is extensive, it should, by no means, be considered a panacea. Rather, it is an expansive attempt to highlight several interrelated and important factors that should be considered when virtual characters are integrated in educational settings, without marginalizing peripheral issues that are also important (e.g., the role of the instructor). However, EnALI is not an all-inclusive list of guidelines, principles, or heuristics. We anticipate that designers, researchers, and instructors will adapt and sculpt the guidelines of the EnALI framework into their unique instructional contexts, ultimately kindling future research and design that will expand the framework foundations. For this reason, we invite other theorists, practitioners, and researchers to offer their own recommendations, ideas, and research, in a

concerted effort to enhance the EnALI framework. Since the use of virtual characters spans disciplinary lines, we see this endeavor as a truly multi-disciplinary and collaborative effort, harnessing the knowledge and expertise of colleagues residing in diverse academic circles. Essentially, we invite, and welcome, others to use, and via their work, validate, critique, and extend this framework.

Finally, we believe that investigating the efficacy of the identified guidelines (empirically, theoretically, or philosophically), can feed back into enhancing the identified framework, which can then be used to enhance practice and direct future research. Three ways that we are attempting to critique and extend this framework are via (a) controlled experiments that evaluate individual guidelines and measure the impact of each variable, (b) interpretive research investigations that enable us to gain a rich understanding of the meaning of these guidelines, and (c) a design-based research approach maintaining ecological validity in which we deploy pedagogical agents in varied research programs (e.g. Authors, 2007) and iteratively and continuously refine their design. Such questions may include, (a) What is the impact of the agent interjecting off-task commentary on learning and agent-learner interaction (controlled experiment or mixed method study), (b) What is the lived experience of learners interacting with agents whose visual appearance is not appropriate to the content (interpretive-phenomenological research), and (c) How can pedagogical agents best engage learners in learning history (design-based research). A concerted multi-disciplinary and multi-methodological effort at reducing conflicts between pedagogical agents and learners, ultimately enhancing the ways learners interact with agents, will pave the way for truly effective and engaging virtual companions.

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