

**WHAT DO LEARNERS AND PEDAGOGICAL
AGENTS DISCUSS WHEN GIVEN OPPORTUNITIES
FOR OPEN-ENDED DIALOGUE?**

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ABSTRACT

Researchers claim that pedagogical agents engender opportunities for social learning in digital environments. Prior literature, however, has not thoroughly examined the discourse between agents and learners. To address this gap, we analyzed a data corpus of interactions between agents and learners using open coding methods. Analysis revealed that: (1) conversations between learners and agents included sporadic on-task interactions with limited follow-up; (2) conversations were often playful and lighthearted; (3) learners positioned agents in multiple instructional/social roles; (4) learners utilized numerous strategies for understanding agent responses; (5) learners were interested in agents' relationship status and love interests; and (6) learners asked personal questions to the agent but did not reciprocate to requests to talk about themselves.

In recent years, interest in pedagogical agents has increased dramatically as video games, virtual worlds, and advanced learning technologies, and by extension the virtual characters that inhabit these environments, have become popular in educational settings (de Freitas, 2008). Pedagogical agents are virtual characters employed in digital environments for instructional purposes, like modeling, scaffolding, information delivery, and motivational support.

Researchers claim that agent-learner conversations engender social learning affordances, though the evidence supporting these claims is mixed (Gulz, 2004; Veletsianos & Russell, in press). The social affordances of pedagogical agents can be better understood through analyses of agent-learner conversations, but the social discourse that occurs between agents and learners is generally overlooked in the education literature (Veletsianos & Miller, 2008). This oversight is important: discourse includes both explicit and concealed meanings, and an investigation of these meanings may illuminate current perspectives on and generate deeper understandings of agent-learner interactions and relationships.

The goal of this study is to examine the nature and content of interactions between learners and pedagogical agents, using a case in which pedagogical agents were integrated into a higher education course. Our aim is to better understand learner-agent conversations within the specific context in which we deployed the pedagogical agents. First, we review related literature. Next, we describe our research questions, methods, and findings. We conclude with implications of this work and suggestions for future research.

REVIEW OF RELEVANT LITERATURE

A theoretical perspective known as the *media equation* or *Computers Are Social Actors* (Reeves & Nass, 1996) has guided research in the pedagogical agent field. This perspective arose from research showing that humans treat and interact with media in ways that approximate the interactions that humans have with other humans (Reeves & Nass, 1996). In other words, users' social responses toward digital media tend to approximate social responses directed toward other humans. For example, research showed that rules of politeness apply when humans interact with computers (Nass, Moon, & Carney, 1999). Nonetheless, most of the scholarly work on pedagogical agents has focused on cognitive concerns (Veletsianos & Russell, in press) and only recently have researchers called for an increased emphasis on socio-cultural investigations (Krämer & Bente, 2010).

Such calls are grounded on the notion that agents add social enrichment to digital learning environments (Kim & Baylor, 2006), a feature that Kreijns et al. (2003) consider to be a foundational element of successful digital learning environments. Examples of socio-cultural investigations in the literature include research relating to the possibility of agents establishing and maintaining long-term relationships with learners (Bickmore, 2003) and the influence of agent visual appearance on learner perceptions of agent expertise (Veletsianos, 2010). However, socio-cultural inquiry into pedagogical agents has been hampered by the use of pedagogical agents who are programmed to focus exclusively on the pedagogical task and the domain content (Veletsianos & Russell, in press). The focus on task-oriented agents in the literature is in contrast to the vision of participatory, student-centered, and community-oriented learning

experiences (e.g., U.S. Department of Education, 2010). The potential for agents to successfully engender social learning environments is limited when learner-agent activity is restricted to one-way interactions (e.g., cases in which the agent delivers a lecture). Pedagogical agents that are able to engage in social-oriented dialogue with learners may play an important role in digital learning contexts, but opportunities for social-oriented dialogue may also distract learners (Veletsianos, 2012).

When learners are given access to pedagogical agents capable of engaging in dialogue, designers and researchers hope for pedagogical purposefulness to their interactions. Graesser and colleagues for example, note that well-designed agents are capable of “reasonably smooth and pedagogically effective conversation” (Graesser, Jeon, & Duffy, 2008, p. 301) that may include valuable pedagogical strategies such as asking guiding questions, prompting reflection, providing feedback, summarizing information, and modeling desired behaviors (Baylor & Ryu, 2003; Choi & Clark, 2006; Moreno, Mayer, Spires, & Lester, 2001). These scaffolds may focus learners’ attention on critical concepts, which in turn may result in additional domain-related discussions (Moreno et al., 2001; Robinson, Traum, Ittycheriah, & Henderer, 2008). Furthermore, unscripted interactions between agents and learners may enable agents to address student misconceptions as they arise in conversations (Anderson, Davidson, Morton, & Jack, 2008; Graesser et al., 2008; Moreno et al., 2001).

The development of agents that exhibit human-like attributes and are capable of participating in high-quality conversations is another theme in the literature. Human-like attributes are often expected to contribute to desirable outcomes, such as alleviating anxiety (Gulz, 2005; Gustafson & Bell, 2005), though the literature also notes that pedagogical agents with human-like attributes may introduce expectations of the agents having human-like intellect that may disappoint users if agents are not able to meet those expectations (Norman, 1997; Veletsianos, 2010). This is especially important when agents are portrayed as content experts, because in these situations students expect correct responses to their inquiries (Baylor & Kim, 2005). Nonetheless, agent designers use a variety of conversational and non-conversational strategies to make interactions more natural and human-like, potentially leading users to treat such conversations more like human-human than human-computer conversations (Bickmore & Cassell, 2005). Such strategies have included agents’ use of first and second person points of view in their speech (Anderson et al., 2008, Bickmore & Gruber, 2010), the vernacular via phrases like “yippee” or “you know” (Bickmore & Cassell, 2005; Moreno et al., 2001), and physical cues such as eye gaze, body posture, hand gestures, and facial displays (Bickmore & Cassell, 2000). Additionally, empirical studies suggest that humor makes agents seem more likable, competent, and cooperative (Bickmore & Cassell, 2000, 2005; Moreno et al., 2001) and an agent’s positive attitude correlates with engagement and perceived quality of facilitation (Kim, Baylor, & Shen, 2006). However, the potential for misunderstandings

looms, which can be detrimental to agent-learner relationships. For instance, Bickmore and Cassell (2005) found that their agent's nonverbal behavior inadvertently projected unfriendliness, while Doering, Veletsianos, and Yerasimou (2008) found that agent-learner conversations initially made learners apprehensive and anxious because users perceived the agent as intelligent entities.

While agents and learners have been observed to frequently engage in social-oriented conversations, Graesser, Jeon, and Duffy (2008) found that when learners are given opportunities to guide the conversation, they ask off-topic questions. For example, learners often want to know about agents' operating systems, design, purpose, and capabilities (Doering et al., 2008; Robinson et al., 2008). Such conversations encompass the "testing" of agents' abilities and resolve wherein learners are attempting to discover the boundaries, limits, and capabilities of agents through "game-like" inquiry (Robinson et al., 2008). Learners also exhibit curiosity about agents' preferences (e.g., favorite color) and biographical information (e.g., birthplace). In one study, researchers found that the overwhelming majority of student questions (97%) were about biographical information, personal experiences, preferences, and opinions (Robinson et al., 2008), while Gustafson and Bell (2000) found that about one-third of user utterances ($n = 10,058$) were social in nature (greetings and personal remarks, excluding insults). Though social agent-learner conversations may veer learners away from intended conversation topics, researchers have also argued that social conversations can foster the development of agent-learner relationships (Baylor, 2000) and interactions (Veletsianos, Miller, & Doering, 2009). For example, the presence of conversational "small talk" (e.g., greetings, discussions about the weather or pop culture) may act as a transitional function that helps agents establish common ground, closeness, and rapport with learners, effectively "greasing the wheels" (Bickmore & Cassell, 2000, p. 1) for future on-task conversations. While the literature demonstrates that agent-learner interactions encompass off-task behaviors, only a limited number of studies examine agent off-task behavior or learners' experiences with and perceptions of off-task agents (Veletsianos, 2012). In one study that sought to examine this issue, learners deemed off-task interactions to be memorable but distracting, and additional off-task comments during a presentation delivered by an agent were related to lower learning outcomes and poorer perceptions of the agent's interaction abilities (Veletsianos, 2012). However, it is important to note that even though the literature describes a tendency for learners to engage in social interaction with agents, this result might not apply to all learners. For example, Gulz (2005) asked 90 adolescents to choose between a task-oriented and social-oriented agent and approximately 41% of learners stated that they would prefer a strictly task-oriented agent, arguing that such an agent would keep them focused on the task while avoiding unnecessary conversations and meaningless interactions.

Prior research also demonstrates that off-task interactions may not always be appropriate. Though the use of pedagogical agents occurs in educational settings,

learners can be direct with their attacks, using insults, hazing, flaming, and sexual harassment (Brahnam & De Angeli, 2008; Veletsianos, Scharber, & Doering, 2008). For example, topics of conversation sometimes include drugs/illegal substances and sexual references, and users can appear to be disinhibited when conversing with agents (De Angeli, 2009). In these instances, the opportunity for open-ended dialogue is not fostering social enrichment or the development of productive agent-learner relationships.

Finally, the literature is replete with instances of ineffective interactions between agents and learners (Graesser et al., 2008). For example, agents may respond incorrectly or refrain from communicating altogether. This problem is often associated with limitations in agents' knowledge and abilities (Doering et al., 2008). For instance, misclassification of user input can lead to agent responses that do not fit within the context or structure of the conversation. Agent-learner discourse might also be hampered by agent behavior that is perceived to be non-polite, such as rudely entering conversations, leaving conversations abruptly, or exhibiting a persistent presence. For instance, Microsoft Word's "Clippy" character often interrupted users to offer unsolicited advice resulting in user annoyance and apprehension (Graesser et al., 2008). In another case, Baylor and Ryu (2003) noticed that some learners in their study assumed that the agent was angry if it left without warning.

The studies synthesized above reveal an intricate relationship between learners and agents. While social interactions might enrich agent-learner relationships, such interactions are not always welcome, and can have unintended consequences (such as learner frustration) and/or be distracting. Qualitative inquiry into this topic will further inform researchers on the nature and content of agent-learner discourse. Unique contributions of this research include an understanding of the types of pedagogical and social discourse that occur in this context, an understanding of the ways learners use language to shape their interactions with agents, and an understanding of the ways technology shapes learner-agent interactions.

RESEARCH QUESTION

The research question posed in this study was: What is the nature and content of interactions when adult learners are given opportunities to converse with pedagogical agents in open-ended dialogue? As such, this study does not intend to evaluate the effectiveness of the pedagogical agent on a specific outcome or participants' performance as a result of interacting with pedagogical agents.

METHODS

Participants

Participants consisted of 52 elementary education students enrolled in a post-baccalaureate masters program in education at a large U.S. university. Forty-five

of these participants were women and seven were men. Those who reported their age (47) ranged in age from 21 to 50 years old (mean = 23.43, $SD = 5.06$).

Pedagogical Agents

Two pedagogical agents (one male, one female) were used in this study (Figure 1). Agents were assigned to courses and students had access only to the agent assigned to their course (two courses in total). Learners conversed anonymously with the agents.

The agents were presented as content experts, and their role was to answer questions and provide conceptual and procedural assistance to learners tasked with developing an electronic portfolio. The electronic portfolio was a course requirement for students to submit in order to earn their teaching license. Learners interacted with agents by typing text. Agents responded back via text responses and audio responses generated by a text-to-speech engine. In addition, agents' lips were synchronized to move with their audio responses, and their head and eyes would gaze at the mouse as it moved around the screen. The agents' eyes could also blink, but their torsos were not animated.

Participant input was unrestricted; students could inquire about any topic that was of interest to them at the time of interaction. Agents were able to respond to student queries by accessing a knowledge base created through the Artificial Intelligence Markup Language (AIML). The agents were modified versions of the 2002 Artificial Linguistic Internet Computer Entity (A.L.I.C.E.) implementation. The characters' personalities, biographies, and knowledge were expanded and customized to fit the needs of the research, but the agents' encyclopedic knowledge was largely provided by the A.L.I.C.E. AIML set. Agents were also



Figure 1. The pedagogical agents used in the study.

provided with in-depth content-specific information about electronic portfolios in order to answer questions about them. While the quality of the dialogue generated by the A.L.I.C.E. AIML set is human-like, it is not perfect and user inputs are not always fully understood. However, because this technology is freely available and used by other researchers/designers in the field (e.g., Heller & Procter, 2010; Schumaker, Liu, Ginsburg, & Chen, 2006), we considered the system, and its imperfections, to be ecologically valid.

Data Sources

The data sources informing this study were agent-learner conversation logs, collected over a 4-week period during which learners had access to the pedagogical agents. These logs amounted to 4,360 exchanges between the agents and students (2,236 with the female agent, and 2,124 with the male agent), with half of those being student utterances and half being agent responses.

Data Analysis

Methodologically, this is a basic interpretive study (Merriam & Associates, 2002). Under the interpretive research paradigm we analyzed the content of the logged conversations between learners and agents using the constant comparative method (Glaser & Strauss, 1967) to develop salient categories and data patterns. Both researchers engaged in open coding of all the data, independently reading and analyzing the corpus to note emerging patterns with regards to conversational practices. We then met 11 times to discuss identified categories, compare notes, and collaboratively analyze data in search of common themes and meanings. The patterns we discovered were compiled and reanalyzed in order to confirm and disconfirm the codes across the transcripts. Open coding of the data resulted in 77 codes relevant to the research questions. For example, the student comment “what do you like to eat?” was coded six times:

1. about the agent;
2. anthropomorphic;
3. personal;
4. preference;
5. request for opinion; and
6. small talk.

We continued the analysis until we could not identify any new coding categories and felt that the data had been completely represented by the final codes (i.e., the data was saturated). Once patterns were identified, we grouped them into themes.

Triangulation and Rigor

The following strategies were employed to reduce the possibility of researcher bias in drawing conclusions from the data and enhance the study's rigor and trustworthiness:

- Researchers analyzed data independently (as a check on individual biases) and only after individual analysis was completed did they start meeting to compare and discuss findings.
- To reduce the possibility of researcher's pre-understandings of the topic influencing the analysis of data, the researchers engaged in a process known as bracketing (Giorgi, 1997) which is a disciplined effort to consciously contain (i.e., "bracket") previous understandings of studied phenomena.
- A conscious effort was made to provide enough information and "thick descriptions" of agent-learner conversations to enable readers to evaluate the extent to which the results are applicable to other populations and "determine how closely their situations match the research situation, and hence, whether findings can be transferred" (Merriam, 1995, p. 58).
- Once the two researchers created the codes, a description of each code and a 20% random sample of the dataset were given to a third researcher who (a) coded the dataset with the list of 77 codes, and (b) investigated whether any additional codes could be used to describe any part data. The third researcher analyzed and coded the data independently. Intercoder reliability was calculated at a Cohen's kappa coefficient of .65. Values between .40 and .75 are considered to be fair to good. A comparison of the codes applied by the coders suggests that the large number of codes (77) and the fact that multiple codes were applied to single utterances in the transcripts might have been the contributing factors to the coefficient of .65. In a debriefing session conducted with the third researcher, this person noted that all data "fell within the existing codes" and that he was not able to "see anything that was outside of those codes." Coding disagreements were discussed and it was agreed that no more thematic categories could be identified from the existing data.

RESULTS

Analysis of the data corpus revealed six themes. These themes describe the nature and content of agent-learner interactions in the specific context described above. The six themes are:

1. Conversations positioned agents in multiple instructional and social roles;
2. Agents' relationship status and love interests;
3. Playful commentary;
4. Working toward understanding;

5. Learners asked agents personal questions, but were unresponsive to agent requests to talk about themselves; and
6. Sporadic on-task interactions with limited follow-up.

Conversations Positioned Agents in Multiple Instructional and Social Roles

Transcript analysis suggests that learners ascribed multiple and transitory (rather than fixed) instructional and social roles to pedagogical agents. This finding is important when juxtaposed with current pedagogical agent literature that discusses agent roles as permanent, monolithic, and ascribed by agent designers. For example, Payr (2003) notes that pedagogical agents can be designed to represent digital instructors, tutors, learning companions, and co-learners, and Baylor and Kim (2005) suggest that agents can encompass specific instructional roles, such as experts, motivators, and mentors. Results from this investigation, however, indicate that: (a) learners ascribed roles to agents, (b) agents took on multiple roles, and (c) agent roles varied between users *and* within conversations with one conversational partner. Specifically, we observed five agent roles: conversational partner, instructional expert, information broker, expert system, and playmate. These are described below.

Conversational Partner

In the conversational partner role agents were expected to respond to a variety of social topics. Participant questions that positioned agents in a conversational partner role included the following: “Do you want to have children?” “Do you believe in Hinduism?” and “Do you agree with drilling for oil in Alaska?”

Instructional Expert

The instructional expert role describes the agent that is expected to have knowledge about the learning situation (e.g., “How do you add pictures [to the electronic portfolio]?” “How can I gate [password-protect] a section [of my website]?” and “What is the purpose of the portfolio?”). Data also suggest that when the agent repeatedly failed to answer a content-related question (i.e., fulfill his/her instructional expert role), learners continued to engage the agent in conversation, but positioned the agent in a different role, usually a conversational partner role.

Information Broker

The information broker role describes cases in which the agent was expected to provide information about others (e.g., “Who has the best [electronic portfolio] page?”) or mediate between individuals (e.g., Agent: Maybe [instructor]

knows the answer; Participant: ask him; Agent: Ok I will ask him when he comes back; Participant: please get him).

Expert System

The “expert system” role describes the instance where the agent was expected to provide encyclopedic information (e.g., “What is autism?” and “What is a soft return?”) and behave in a manner akin to a Question & Answer data bank. This role was consistent with the role designed for the pedagogical agent (i.e., an electronic portfolio expert).

Playmate

Finally, the agents were positioned in a playmate role wherein the learners engaged in playful conversations with him/her. Humor and sarcasm were often involved, such as in the following case:

Participant: Maybe you could exercise.

Agent: Perhaps. I could but let’s get back to that later.

Participant: You are getting a little fat.

Agents’ Relationship Status and Love Interests

Learner questions pertaining to the agent’s “relationship” status and love interests were a popular topic of conversation. For example, the questions “Are you single?” (or, “Are you married?”) and “Do you have a [boyfriend/girlfriend]?” were asked often. Related questions would regularly focus upon how the agents felt about other agents or individuals that the learner seemed to know. For instance, the male agent was asked “Do you like [the female agent]?” and “Do you want to date Mary [a student]?” The agent was also asked “Are you good with the ladies?” and was told that the learner “know[s] a girl that likes you.” The female agent was asked if she “want[s] to date Spencer [a student]?” “If she hit on Jake [a student]?” and if she “likes” the male agent? Additionally, the learners seemed eager to explore agents’ past relationships and experiences. For example, the female agent was asked “How many boyfriends have you had?” and “What was your 1st boyfriend’s name?” The male agent was asked “What type of girls do you like?” and “How come you don’t have a girlfriend?”

Numerous questions and comments pertaining to agents’ relationships and love interests were categorized as inappropriate. Such commentary was often related to sex. For example, participants asked and commanded the agents to engage in sexual acts. We also observed instances in which comments were insulting but not sexual. For example, participants told the agent to “shut

up” while also noting that the agent was “smelly” and a “loser.” Nonetheless, unlike findings in prior literature that have shown pervasive use of insults toward agents (e.g., Veletsianos et al., 2008), the presence of insults in this study was infrequent.

Playful Commentary

This theme refers to instances in which learners engaged in conversations that were unrelated to the task of creating an electronic portfolio and were lighthearted, amusing, and humorous. These comments appear to be innocent rather than malicious in nature, and were scattered throughout the data corpus. Seen in context of the broader conversation, we understood such comments to be steps aimed at building rapport and relationships, and geared toward exploring the agent and its capabilities. Unlike the playmate category identified above that relates to the agent’s *role*, this category relates to the types of conversations occurring between agents and learners.

Playful commentary occurred in the context of both educational and non-educational conversations. Some conversations, though still playful, were related to students’ lives at college. For example, one participant asked the agent to predict whether s/he will “get an A in my test tonight?” and a second participant jokingly asked the agent: “Would you like to take my midterm for me?” Other learners asked questions that were unrelated to educational matters. One participant told the agent that s/he has “two kids, but I am in love with you!” while a second one, after asking the agent his age, pointed out that s/he “was just checking [the agent’s] math skills.” The agent was programmed to gaze at the mouse as it moved on the screen and one user asked the agent whether s/he “enjoy watching my cursor move on the screen?” and followed that up with “Is there anything you don’t [sic] like?” A number of users commented on the agents’ appearance, with one of them informing the agent that s/he liked their outfit and a second one asking the male agent whether he has “a mullet.” Finally, users also appeared to be sarcastic and use colloquial speech in their interactions with the agents. One participant asked the agent “How is living in a computer, kinda cramped?” while another exclaimed that “Maybe you could exercise.” Additional playful expressions included: “Yes siree,” “Oh shush,” and “Fine, whatever.”

Encyclopedic questions posed to the agents were also often asked in a playful manner. Importantly, it appears that learners did not necessarily ask encyclopedic questions for the purpose of gaining knowledge or finding information. Rather, it appears that the purpose of encyclopedic questions was to evaluate or test the agent’s knowledge, understanding, reasoning, and technological capabilities. For example, the questions “What is the last question I asked you?” “What

is 1+1?” “What is the Roman empire?” and “What time is it?” appear to be evaluative of the technology.

Working toward Understanding

During conversations, learners asked a variety of questions to clarify information and alleviate confusion. These questions occurred in both on-task and off-task conversations. In these conversations, misunderstandings often appeared to be the result of a statement’s lack of context. For example, in the following interaction there are no contextual references to “reductionism,” resulting in the learner expressing confusion:

Agent: I am originally from [U.S. City, State]. Now I live in here. Where are you?

Participant: Why

Agent: Reductionism

Participant: huh

At other times, confusion is the result of poor syntax, including the poor use of verbs, pronouns, or diction, as in the following example, in which poor word choice leads to the participant being confused, again:

Agent: Oh, you were born in the 20th century!

Participant: more than I can say for you

Agent: That seems like quite a lot.

Participant: of what

Questions were also asked for clarification purposes. When some learners sensed that the agent might not completely understand the question, they altered their original statement or question slightly. For instance, in the following exchange, an incorrect response leads to the participant asking the same question with a different keyword (i.e., by replacing the word “link” with “connect”), suggesting that the learner felt that the use of a different keyword might yield a more successful outcome:

Participant: How do I link my efolio to another webpage?

Agent: “To add a link to your efolio you need to follow some simple steps. To make it easier, I have created a movie for you. Click here to watch this movie.”

Participant: How do I connect my efolio to another webpage?

On the other hand, learners sought to clarify questions already asked by making them more specific. For instance,

Participant: where can i find the rubric

Agent: The rubric? Where is it?

Participant: where can i find the rubric for the efolio project?

In this instance, the agent required greater detail in order to understand user input, and the learner provided additional contextual information after it was indicated to him/her that their input wasn't understood.

Finally, we observed numerous instances in which the learners persisted in their desire to gather information on a topic, even when the agent was unable to provide it or appeared uncooperative. For example, one participant stated that she needed "to know about the roman empire" and in her subsequent conversation with the agent noted that she needed this "extensive information" for the purpose of writing "a paper." Despite using various strategies to elicit appropriate responses, agents and learners did not always reach mutual understandings, and at that point, the conversation moved on to another topic chosen by either party.

Learners Asked Agents Personal Questions, But were Unresponsive to Agent Requests to Talk about Themselves

Our analysis shows that learners appeared eager to learn about the agents' background and biography, but were unresponsive to inquiries about their own lives or thoughts. For example, learners frequently asked about agents' personal history ("Are you single?" "Have you ever been to Mexico?"), their opinions ("What color should I paint my fingernails?"), their preferences ("What is your favorite car?" "Do you like bacon?"), and their current and future plans (e.g., "What are you doing for spring break?"). On the other hand, we observed very few instances of learners sharing personal information about themselves with the agents. For example, when agents asked questions, they were generally ignored. Instead of replying to agents' questions, learners often continued asking their own questions about the agent or asking about other topics entirely. This case is evident in the following example:

Participant: Where do you live?

Agent: I live inside a computer. Where are you?

Participant: What kind of car do you drive?

Ignoring a reciprocated question might seem rude in a human-human conversation, especially since the first speaker chose the conversational topic. However, in this instance, the learner ignores it. In some cases, learners even verbalize their refusal to respond to agent inquiries:

Agent: Tell me a little about your life in class.

Participant: no

It is not unreasonable to expect that certain agent questions/comments will be ignored, as in the case of statements that are confusing or deviate from the topic of conversation. Nonetheless, in the examples above, this is not the case. Thus, even though participants exhibited an interest in learning more about the agent, his/her interests, and biography, they showed little inclination in sharing their opinions or sharing information about themselves. In general, our analysis suggests that learner behaviors do not appear to mimic the conversational patterns of human-human interactions when learners are asked to share personal details. It is also possible that participants did not share personal information with the agent because of privacy concerns or a preference to keep conversations anonymous, or at least non-identifiable.

Sporadic On-Task Interactions with Limited Follow-Up

Although the pedagogical agents were created to assist with a specific educational purpose (the creation of an electronic portfolio), learner questions and comments relevant to this task were limited and sporadic. These on-task conversations were short, and the majority of them were procedural (e.g., “How do i add content [to my electronic portfolio]?”) or factual (e.g., “What is efolio?”). Participants tended to ask on-task questions in the middle of conversations, but rarely did they begin their conversations with these questions or acknowledge the agents’ responses, and never did they ask follow-up questions (other than for the purpose of clarifying their original question as described previously). In the cases in which an agent’s response did not answer a learner’s question, the learner either reformulated his/her question or changed the topic of conversation. In the few cases that learners reformulated their questions, they did not persist for more than a second attempt. Specifically, we observed three modes of on-task interaction, summarized in Table 1.

IMPLICATIONS AND DISCUSSION

These themes uncover the complex and negotiated relationships that exist between pedagogical agents and learners, and illuminate the types of conversations that occur when learners are given opportunities for open-ended interaction with virtual agents. These findings lead us to draw three implications for future research and practice.

Our results regarding agent roles differ in two ways from existing knowledge. Specifically, prior literature focuses upon agents that have single and

Table 1. Models of On-Task Interactions

Mode descriptions	Sample interaction
A participant asks a question, the agent provides a correct detailed response, and the participant changes the topic.	<p>Participant: how do i add content?</p> <p>Agent: Login to the admin portion of your efolio. This will require you to enter your username and password. Find the Content Tools tab and click on it. On this page you can choose which section you want to enter information into either enter text in the Section Introduction text box or add text as an Item. Also, you can either type information into the text box directly or you can cut and paste information into the text box from another electronic document.</p> <p>Participant: How are you?</p>
A participant asks a question, the agent asks a clarifying question or gives an incorrect response, and the participant reformulates their question.	<p>Participant: How do I link my efolio to another webpage?</p> <p>Agent: To add a link to your efolio you need to follow some simple steps. To make it easier, I have created a movie for you. Click here to watch this movie.”</p> <p>Participant: How do I connect my efolio to another webpage?</p>
A participant asks a question, the agent asks a clarifying question or provides an incorrect response, and the participant changes the topic.	<p>Participant: how can i change my efolio template?</p> <p>Agent: [incorrect response]</p> <p>Participant: where do you shop for your clothes?</p>

monolithic roles (e.g., a motivator, an expert) that are prescribed by designers (e.g., Payr, 2005). Alternatively, in this study we find that an agent may be positioned in multiple roles, the agent's role is transitory, and the agents' role is negotiated between agent and learner. Not only did these roles vary within conversations and from learner to learner, but learners rapidly positioned agents in different roles. Though agents can be designed to employ specific roles, learners may not necessarily view them in those roles and may ascribe agents' roles that they define themselves. For instance, while the agents in this article were presented and positioned as content experts, students assigned multiple roles to them. It is important to note that the potential for agent roles to vary is limited when the ways that agents interact with learners are scripted and interactions are pre-determined (e.g., in the cases where the agent acts as a presenter).

This understanding has important implications for pedagogical agent scholarship because the role in which agents are positioned is likely to influence the interactions between agent and learners, and hence the agent's effectiveness. It will be worthwhile for future research to examine pedagogical agent roles as described above, investigating not just permanent and transitory agent roles (e.g., the agent as an instructional expert), but also the degree to which various variables (e.g., an agent's outfit or gender) influence the roles in which agents are positioned. For example, agent role in this study may have been mediated by agent appearance and dialogue quality. Future research could ask: How do variables such as conversational quality and appearance (e.g., gender, ethnicity, etc.) shape the roles learners ascribe to pedagogical agents? How does the appearance of the agent influence learner perceptions of the agent's role, and ultimately the ways learners interact with agents?

The second implication that we draw from our work relates to the role of off-task and non-task interactions in agent-learner conversations. If the agent is intended to function as a didactic tool, then designers should seek ways to minimize off-task conversations or even open-ended interactions. However, both this and prior research show that a large proportion of open-ended interactions between agents and learners are social (Gustafson & Bell, 2000; Robinson et al., 2008) and perhaps worthwhile since non-task conversations are often used to establish rapport and build relationships (Veletsianos, 2012). Kreijns, Kirschner, and Jochems (2003), for example, argue that one reason that digital learning environments fail is due to socio-emotional processes being "ignored, neglected, or forgotten" (p. 336). Thus, attempts to thwart non-task conversations may be entirely misguided. How can designers capitalize on non-task interactions to foster socio-emotional connections between learners and agents? One way is to utilize student interest relating to the agents' personal life in order to pull students into the topic of study through narratives. Though the use of narratives and stories is an emerging form of practice in instructional settings (Hokanson

& Fraher, 2008), it appears that they may be worthwhile vehicles to investigate in agent-based learning environments. Bickmore, Schulman, and Yin (2009), for example, have studied agents who share autobiographical stories and have found that, compared with users whose agents shared stories in the third person, users who interacted with agents that shared autobiographical stories in the first person completed more conversations with the agent. The use of narratives might also enable agents to relate to learners on a more personal level, thus supporting interactions and social enrichment.

Finally, whereas learners in this study appeared to treat the agents in ways that demonstrate human-human rapport and interaction, they also exhibited apathy toward sharing information about themselves. The reasons for this apathy are not evident using this article's data sources. Future research should examine this phenomenon more closely using data that allows for drawing inferences as to the reasons why users may not reciprocate such information. Why did learners not engage in this activity? What were their reasons for not reciprocating? While these questions are unimportant in cases where there is no dialogue between agents and learners, they become especially important to answer in mixed-initiative dialogue environments, because learners will ask off-task questions of the agents (Graesser et al., 2008), as in the case of this article. Importantly, while the pedagogical agent literature has generally been grounded on the Computers Are Social Actors paradigm that suggests that users treat media in a human-like fashion (Reeves & Nass, 1996), ours is a case in which users ignored agent questions, which might signify that the relationship between agents and learners might not be perceived by learners to be equivalent to a human-human relationship. If this is indeed the case, the field is in need of both empirical research that examines these issues in more depth as well as in need of theoretical frameworks that more fully explain agent-learner interactions and relationships.

CONCLUSION

In this study we sought to understand the nature and content of interactions when adult learners are given opportunities to converse openly with pedagogical agents. We observed that conversations included sporadic on-task interactions with limited follow-up, positioned agents in multiple instructional and social roles, and included playful commentary. Learners utilized strategies for understanding, appeared to be interested in agents' relationship status and love interests, and asked personal questions, but did not reciprocate to requests to talk about themselves. These findings may not generalize to all settings, and readers are encouraged to examine the extent to which their settings match the context of our study and thus the degree to which these findings are transferrable. Moreover, the data collected for this study allows us to report on

the nature and content of interactions, but does not allow us to report why such behaviors occur. Future research may examine these reasons by using appropriate methodology.

Readers should be cognizant of the limitations of this study. First, learners may interact differently with male and female agents and this study did not evaluate the differential impact of the male vis-à-vis the female agent. Second, about 86% of this study's participants were females, and this may have had an impact on the nature and content of interactions. Third, the agents' personality may have impacted the ways learners interacted with the agents, and readers need to consider the potential impact of this variable. Finally, the pedagogical agents were presented as experts and results might differ if they were designed and presented as having a different role (e.g., peers).

The importance of this study, however, lies in understanding the nature and diversity of interactions that occur in environments in which learners are able to engage in open-ended dialogue with agents. Armed with this knowledge, future research can examine why learners engage in these interactions, what is the impact of these interactions on learning, engagement, and relationship-building, and how these practices can foster effective learning environments.

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