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How does a contextually-relevant peer pedagogical agent in a learner-attenuated system-paced learning environment affect cognitive and affective outcomes?

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Abstract: Educational technology is becoming ubiquitous in schools, thus presenting new challenges in the classroom. For instance, teachers may struggle to find ways to motivate students to learn in multimedia learning environments. One plausible solution is the use of pedagogical agents, which are characters meant to facilitate learning in multimedia learning environments. This study examines the impact of a contextually-relevant, peer agent compared to a condition which provided narration and concurrent keywords displayed on the screen. The findings revealed no statistically significant differences between the two groups. The results, in part, support the presence principle of multimedia learning. However, the results do not suggest that a pedagogical agent is deemed a seductive detail, or distraction during the learning task. Rather, the agent's presence does not have any significant effect on learning or affective outcomes.

Keywords: learning environment, cognitive outcomes, affective outcomes, motivation, learner-attenuated

I. Introduction.

Shapley, Sheehan, Maloney, and Caranikas-Walker (2011) noted that "the present vision…imagines technology's infusion into all aspects of the educational system" (p. 299). Accordingly, it is not surprising that many researchers investigate the question of how we can most effectively use technology to enhance teaching and learning (Barreto & Orey, 2013). Perhaps the most iconic example of technology use in schools is the notion of online learning, which is now a commonplace in K-12 schools (Watson, 2005). For example, in the 2007-2008 school year, more than one million K-12 students were enrolled in online courses (Picciano & Seaman, 2009), and in 2009 there were 29 different states that had at least one virtual school (Hightower, 2009).

A challenge now faced by both educators and academics is how we will engage and motivate students to learn with multimedia and the Internet as technology changes how we communicate and learn (Archembault & Crippen, 2009). This gives rise to a new challenge: how to present the learning material to students. Researchers have dozens of technology tools at their disposal, such as learning management systems, message boards, videos, slide-shows, and interactive websites. One innovative tool now becoming accessible to teachers are pedagogical agents. A pedagogical agent is a visible character which appears in a multimedia learning environment for the purpose of facilitating learning (Moreno, 2005; Schroeder, Adesope, & Barouch Gilbert, 2013). Recently, a meta-analysis has shown that pedagogical agents provide small, positive effects on learning compared to non-agent environments (Schroeder, Adesope, &

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Barouch Gilbert, 2013). While pedagogical agent research is limited at this time, teachers may find them useful in the classroom as the agents can be customized to fit the instructors' teaching needs.

The purpose of this study was to explore the use of a contextually-relevant, peer pedagogical agent compared to a low verbal redundancy control group. The low verbal redundancy condition provided keywords on the screen concurrently with the provided narration (Adesope & Nesbit, 2012). A recent meta-analysis examining the effects of verbal redundancy showed that when compared to narration alone, the low verbal redundancy environment can improve learning by an effect of $g = .99$ (Adesope & Nesbit, 2012).

There is an important distinction between pedagogical agents and intelligent tutoring systems. For example, pedagogical agents may only provide the instruction they are programmed to present while intelligent tutoring systems are capable of providing adaptive and intelligent responses to student questions, as well as using students' current state of knowledge to offer developmentally appropriate instructions (Ma, Adesope, & Nesbit, 2013; Steenbergen-Hu and Cooper, 2013; vanLenhn, 2011; Veletsianos, Miller, & Doering, 2009). One form of an intelligent tutoring system is known as a conversational agent. Conversational agents differ from pedagogical agents because they can answer student questions (Veletsianos, Miller, & Doering, 2009). Incorporating adaptive features may likely increase not only the cost of implementation, but the time and skills required on behalf of the instructor. To summarize the differences between pedagogical and conversational agents, pedagogical agents provide an instructional monologue, while conversational agents may be more interactive and able to individualize instruction (Veletsianos, Miller, & Doering, 2009).

It is reasonable to question the use of pedagogical agents when conversational agents are available. Yet, researchers have continued to find novel ways to incorporate pedagogical agents into learning environments. One important delineation is that "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" (Veletsianos, Miller, & Doering, 2009, p. 179). Reconceived, a pedagogical agent may not be appropriate for all learning environments or all learners. Rather, their design and implementation must be thoughtfully guided to enhance learning.

Pedagogical agents can be extremely versatile since they are programmed and designed for specific applications. For instance, researchers have suggested that pedagogical agents can have six different roles in multimedia learning environments, including demonstrating or modeling (Clarebout, Elen, Johnson, & Shaw, 2002). Accordingly, it is not difficult to imagine how pedagogical agents may find their way into instructional materials through a variety of educational domains.

When educators decide to use a multimedia learning environment, they also have to decide what type of pacing it will use. The pacing of the system refers to how the learner experiences the learning environment. Specifically, pacing refers to the speed of the presentation and the control of the presentation. For example, do the learners control when they move on to new material, or does the learning environment provide them with a steady stream of information? Researchers of pedagogical agents have primarily utilized two types of pacing, system-pacing and learner-pacing.

In system-paced learning environments, the learner is generally shown a streaming video clip. Due to the nature of the video clip, the learner cannot pause, fast-forward, rewind, or restart the clip. Instead, the learner watches the clip from start to finish, and some researchers allow the learner to watch the clip more than once. Yet, there are some inherent faults with this type of learning environment. For example, individuals may encounter difficulties if the agent speaks too quickly, speaks unclearly, presents too many ideas, or uses too much complex terminology. If any of these incidents occur, the learner may get frustrated, confused, or stop paying attention entirely. It is also important to note that if the learner's attention wanes for any period of time, they have then missed that portion of instruction. Finally, researchers have suggested that system-paced instruction does not allow the learner enough time to assimilate the new information they are learning with their prior knowledge (Van Merriënboer & Kester, 2005) because they are continuously being exposed to new information, rather than having a short break to reflect on what they heard.

The other type of pacing commonly utilized in pedagogical agent research is learner-paced environments. Learner-paced systems are delineated from system-paced environments because they have buttons the learner can use to rewind, pause or fast forward through different segments of instruction (e.g., Dunsworth & Atkinson, 2007; Kizilkaya & Askar, 2008) as suggested by Mayer (2005b). Due to the segmented nature of learner-paced systems, there are built in 'breaks' where the learner can reflect upon what they learned in the previous segment before moving forward.

While learner- and system-paced environments have been common throughout the literature, not all technology tools create learning environments which fall explicitly into this dichotomy. For example, some internet-based programs can create pedagogical agent learning environments in the form of a streaming, non-segmented video. Yet, these videos also have a pause button and allow the learners' to fast-forward and rewind as necessary to optimize their learning experience. While the buttons to pause, fast-forward, and rewind are iconic of learner-paced environments, the learner does not control the pace of some aspects of the instructional material. For instance, the agent speaks at a pre-determined speed and proceeds to narrate the non-segmented instructional materials from start to finish. Accordingly, one can see how this type of learning environment contains features of both learner- and system-paced instruction. Hence, we feel is it is more appropriate to refer to these types of videos as learner-attenuated system-paced (LASP) instruction.

While researchers have examined the use of pedagogical agents compared to non-agent systems before in learner-paced environments (e.g. Baylor & Ryu, 2003) and system-paced environments (e.g. Mayer & DaPra, 2012), none have utilized a LASP learning environment. For example, Baylor and Ryu's (2003) work examined the affective and cognitive effects of incorporating pedagogical agents compared to a high verbal redundancy, non-agent learning environment. While Baylor and Ryu did not find significant differences in any of the learning outcome measures, they did find that the animated pedagogical agent was found to be significantly more engaging (d=.46, p<.05) and instructor-like (d=.86, p<.05) than the high verbal redundancy condition. Their results also showed that the conditions which included an agent were found to be more credible than the non-agent condition (d=.47, p<.05).

Although Baylor and Ryu's (2003) study was notable for the differences found in affective measures, it did not find significant differences in learning outcome scores between the conditions. More recently, Veletsianos (2007) has argued for the use of contextually-relevant agents. In fact, a recent study found that the visual appearance of agents may impact how they are perceived and how they affect learning (Veletsianos, 2010). In the literature, contextually-relevant agents have been defined as those which appear to fit the instructional domain (Velesianos, 2007; 2010). However, for the purposes of this study we will expand this definition by having the agent appear in a contextually-relevant environment. In this study, the contextually-relevant environment is represented by a virtual classroom. With the aforementioned findings in mind, we examined if the use of contextually-relevant, peer agents would not only facilitate learners' affect as seen in Baylor and Ryu's work, but also facilitate increased learning outcome scores.

Yet another factor in our decision to expand Baylor and Ryu's (2003) work was the control condition, which provided narration as well as verbatim on-screen text. For this study, a low verbal redundancy control condition (narration with keywords displayed on the screen as text) was used, which a recent meta-analysis found to be more beneficial than a fully redundant text and narration condition (Adesope & Nesbit, 2012).

Since the publication of Baylor and Ryu's (2003) work, they have developed the Agent Persona Instrument (Ryu & Baylor, 2005). The instrument has been found to be reliable in the past, and validity evidence for the instrument has been provided through confirmatory factor analysis (Ryu & Baylor, 2005). It is hoped that by utilizing this instrument, we may be able to capture a more accurate picture of how the agents are perceived by learners.

We also expanded previous work through the measurement of learning outcomes. While Baylor and Ryu (2003) administered a performance assessment as the sole means of measuring learning, we have utilized three different learning assessments, a free recall test, a multiple choice test, and a transfer test in the hopes of isolating the skills of retention and transferring the knowledge to a practical application. We believe that multiple outcome measures will enable us to examine the robustness of the effects. One additional component we investigated compared to previous work was the measurement of learners' computer-efficacy (discussed below) in order to minimize any measurement error due to the individual's confidence in their ability to use computers.

With a need to extend previous research, this study investigated the following research questions:

1) How does incorporating a pedagogical agent affect learners' free recall, multiple choice, and transfer scores in a LASP learning environment compared to a low-redundancy condition?
2) How does incorporating a pedagogical agent affect learners' perceptions of a LASP learning environment compared to a low-redundancy condition?
3) How does learners' computer-efficacy influence cognitive and affective outcomes when learning with a pedagogical agent compared to a low verbal redundancy condition?

II. Literature Review.

Numerous theories have acted as guides for pedagogical agent research. In this section, we will briefly describe the salient theories and their impact on this particular study.

A. Presence Principle.

Mayer, Dow, and Mayer (2003) claimed that while a pedagogical agent's voice is critical for facilitating learning, its physical image is not. This phenomenon was named the presence principle, and denotes a pedagogical agent's image as a "seductive detail" (p. 811), or a non-essential piece of information for the learning process (Mayer et al., 2003). Accordingly, if the agent's physical appearance is a seductive detail, then it is either ignored (Moreno, 2005) or presents a source of distraction (Mayer et al., 2003; van Mulken, André, and Muller, 1998), both of which can potentially be deleterious for learning.

Yet, not all pedagogical agent research has been so clear cut. In fact, most pedagogical agent research to date has produced mixed results (Domagk, 2010; Heidig & Clarebout, 2011; Moreno, 2005). This has caused some scholars to argue that pedagogical agents may not be cost-effective (Choi & Clark, 2006), or claim that pedagogical agents may make the learning environment too complex (Clark & Choi, 2007). While some scholars have found that pedagogical agents can produce small, positive effects on learning (Schroeder, Adesope, & Barouch Gilbert, 2013), others have found that pedagogical agents do not seem to create significant differences in learning outcomes (Heidig & Clarebout, 2011; Moreno, Mayer, Lester, & Spires, 2001).Yet, it is important to note that most of the research to date has utilized learner-paced learning environments (Schroeder, Adesope, & Barouch Gilbert, 2013). As such, we do not know how agents will affect learning in either system-paced or LASP environments.

The mixed results surrounding pedagogical agents do not only refer to their influence on cognitive outcome scores, but also how agents affect learners' affective responses. For example, Louwerse et al.'s (2008) eye-tracking study found that participants spent more than half of their time looking at the agent, suggesting "this attention does not wane over time" (p. 1253). This finding clearly shows that pedagogical agents are not ignored over time as some have suggested (Moreno, 2005). Pedagogical agents may also act as a motivational tool, as some researchers have suggested that they may provide motivational effects in some situations (Gulz, 2004; van Mulken, André, and Muller, 1998). This could be beneficial for learning, as Moreno (2005) noted that if the motivational benefits outweigh the deleterious effects of distraction, learning will be enhanced.

To summarize, researchers are left to question if pedagogical agents can facilitate learning and affective outcomes. Heidig and Clarebout (2011) argued that this question is simply too broad, as researchers have examined a vast array of different pedagogical agents and learning environments. This study investigated if a pedagogical agent's appearance in a LASP learning environment could facilitate learning compared to a low verbal redundancy, non-agent condition.

B. Social Agency Theory.

Researchers have shown that learning is fostered more effectively in a social agency environment than one of merely pictures and text (Moreno et al., 2001). A social agency environment is one which provides social cues to the learner through its messages, which "can prime the social conversation schema in learners" (Mayer, Sobko, & Mautone, 2003, p. 419). In other words, to foster social agency we should create a human-computer interaction that approximates social human-human interactions.

Researchers have suggested that interactions between humans and computers are likely to be understood similarly by the learner as communication between actual people (Veletsianos, Miller, & Doering, 2009). Researchers have found evidence to support this claim. For instance, Kim, Baylor, and Shen (2007) found that pedagogical agents were seen as social models and were expected to have a personality. Further, Louwerse et al. (2008) found through eye-tracking research that agents were seen as conversational partners (Louwerse, et al., 2008). As such, it is plausible that the student could interpret the pedagogical agent as an instructor, peer, mentor, or coach. Since research has shown that pedagogical agents may be stereotyped by their appearance

(Moreno et al., 2002; Veletsianos, 2007; 2010), it is also plausible that the interpretation of the social interaction can be manipulated by how the agent appears, speaks, and behaves within the learning environment. Purposefully manipulating these variables allows the researcher to control the agent's contextual-relevance. Veletsianos (2007) argued that an agent's contextual-relevance is critical "because it may influence learners' attention and perceptions and degree of agent relevance, seriousness, and authenticity" (p. 374), a claim which the findings of his empirical follow up study reiterated (Veletsianos, 2010).

Examination of the literature showed that contextually-relevant agents have not been commonly researched. For example, Choi and Clark (2006) used a Genie to teach English as Second Language students about English-relative clauses. Other researchers have utilized Genie agent to teach medicine (Cheng et al., 2009), a parrot to teach mathematics or science (Atkinson, 2002; Kizilkaya & Askar, 2008) and an anthropomorphized bug to teach botany (Moreno et al., 2001). Following the definition of contextual-relevance cited earlier, it is easy to see how these agents could be characterized as not contextually-relevant. Furthermore, the broad range of agents used may, in part, explain the mixed findings surrounding the effectiveness of pedagogical agents' for learning (Veletsianos, 2007).

As earlier mentioned, one primary argument against pedagogical agent use is that they may cause distraction (Mayer et al., 2003; van Mulken, André, and Muller, 1998) or make the learning environment too complex for the learner to efficiently process (Clark & Choi, 2007). Both of these arguments hinge on cognitive load theory and its associated principles, which are discussed in the next section.

C. Cognitive Load Theory.

According to cognitive load theorists, the long-term memory acts as the central processor while the working memory processes the novel information brought into the brain from an individual's sensory processes (Kirschner, Sweller, & Clark, 2006; Sweller, 2005). The long-term memory then integrates and stores the new information in structures called schema (Sweller, 2005).

Cognitive load can place mental strain on the cognitive process through three means: intrinsic cognitive load, extraneous cognitive load, and germane cognitive load (Paas, Renkl, & Sweller, 2003; Sweller, 2005; 2010). Intrinsic cognitive load is the mental strain due to the complexity of the learning materials themselves, as intrinsic cognitive load depends on the interaction between the individual's prior knowledge and the novel materials (Paas, Renkl, & Sweller, 2003; Sweller, 2005; 2010). Alternatively, extraneous cognitive load is the result of how the material is presented to the learner, and thus has nothing to do with the materials themselves (Sweller, 2005; 2010). Finally, germane cognitive load can be thought of as useful mental strain, for it is due to the interaction between the learner's prior knowledge and the new information being integrated in the schema (Sweller, 2005).

Scholars who have argued that pedagogical agents may create distraction or create an overly complex learning environment may hinge their arguments on the basis of the agent creating a source of extraneous cognitive load for the learner. The split-attention principle, at face value, would support their claims. The principle suggests that in order to enhance learning outcome scores, all of the information the learner needs should be provided through one source rather than forcing them to split their attention between two sources of information (Ayers & Sweller, 2005). It is easy to see how pedagogical agents violate this principle. For example, Atkinson (2002) utilized a pedagogical agent and worked examples to help teach students about mathematics. Theoretically, this would lead to lower learning outcome scores for the students who worked with the pedagogical agent. Yet, Moreno's (2005) review found that the split-attention principles effects have not occurred in any pedagogical agent studies. According to cognitive load theory, information which is stored in the long-term memory does not utilize additional cognitive resources when the learner is re-exposed to it (Sweller, 2005). Thus, Moreno's hypothesis that the agent's image may be processed to a lesser degree over time is plausible.

III. Method.

A. Participants and Design.

The participants in this study were aspiring teachers taking courses within the College of Education at a large, public institution in the Pacific Northwest. Apriori sample size calculations indicated that in order to obtain a statistical power level of .80 with $\alpha = .05$ and a desired effect size of $d = .63$ (average effect size of the scores for person-like, instructor-like, and engaging extracted from Baylor & Ryu, 2003), at least 32 participants were needed per group. Accordingly, 79 aspiring teachers participated in this experiment for course credit. Thirty eight participants were randomly assigned to the control (non-agent) condition, while 41 participants were randomly assigned to the experimental (agent) condition.

The average age of the participants was 20.85 ($SD = 1.99$) years, and the sample was 77 percent female. The participants self-identified ethnicity data indicate that 76 percent of the sample was Caucasian, 9 percent reported multiple ethnicities, 8 percent was Hispanic, 4 percent was African American, and 1 percent was Native American. Two percent of the participants did not report their ethnicity. The average participant had completed two years of post-secondary education, and 94 percent spoke English as their first language. Five percent of the participants indicated Spanish was their first language, while 1 percent chose not to report their first language. The participants were, as a whole, moderately confident in their ability to use computers. The self-rated computer-efficacy of the participants was 69% ($M = 68.66$, $SD = 13.52$).

Eighty four percent of the participants indicated that they had not received formal instruction on multimedia learning theory. However, the participants indicated that they sometimes use multimedia when teaching ($M = 3.23$, $SD = .89$, where 1 is "never" and 5 is "almost always"). The participants average pretest score was 3% ($M = .48$, $SD = .78$). Accordingly, the participants were considered low prior knowledge learners.

B. Computer-based Materials.

The control group's learning environment (Figure 1) was created using Microsoft Movie Maker. The narration was provided by an American male's voice in a conversational style and provided instruction about multimedia learning theory. The voice was generated using Xtranormal's (2012) text-to-speech feature. In order to create the low verbal redundancy environment, keywords from the instructional materials were displayed on-screen in white text concurrently with the narration. The keywords displayed on-screen matched the main ideas which the students were asked to later recall and use for the post-tests, namely "modality principle", "split-attention principle", and "cognitive load theory" (Figure 1 provides an example).

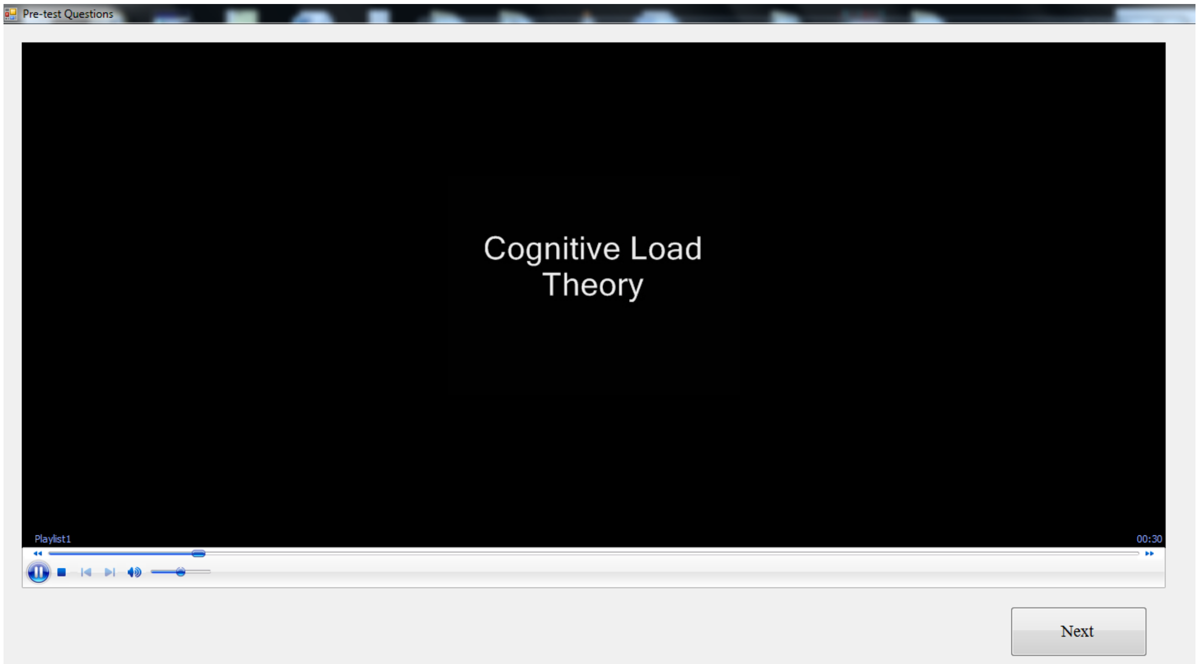

Figure 1. Screenshot of the control group's learning environment.

Xtranormal (2012), as described in the next section, was used to create the experimental condition. In order to create a contextually-relevant pedagogical agent, a male, peer pedagogical agent (Figure 2) was placed in a virtual classroom environment. The narration was identical to the control condition, and the agent's lips moved while it spoke. The pedagogical agent also gestured five times throughout the narrative. While the gestures did not reference any learning materials, they were provided by the agent due to research which has shown that gestures facilitate understanding (Hostetter, 2011) and may foster the agent's deictic believability (Lester, Voerman, Towns, & Callaway, 1999). The agent's deictic believability refers to its ability to move and gesture in relation to objects in the learning environment (Lester et al., 1999), which may facilitate the agent's ability to appear human-like.

The learners were allotted 600 seconds to watch a 240 second instructional video. The excess 360 seconds were provided so that the learners could rewind or pause the presentation as desired. The video was presented by a computer program designed specifically for this study which kept track of how long learners worked with the instructional video. The learners advanced to the post-tests by pressing the "Next" button.

Agent Design.

Xtranormal. While many software programs have been used to create pedagogical agents in the past, Xtranormal (2012)[3] provides an accessible and affordable solution to educators. Some institutions have begun using Xtranormal to a limited extent for online instruction (Miller, 2011; 2012; WSU eLearning Services, n.d.). As the excitement about this program spreads, it is plausible that programs such as Xtranormal will soon be incorporated into K-12 instruction as

[3] Since the writing of this manuscript, Xtranormal has shut down its website and no longer offers the services described in this manuscript.

the implementation of pedagogical agents requires fewer fiscal and knowledge resources than some of the other software options.

Xtranormal (2012) makes it very simple for a new user to create pedagogical agent-based learning environments. The program essentially uses a drag-and-drop methodology. In other words, you do not have to have any advanced computer or programming knowledge to utilize the software. For a description of how to design presentations with Xtranormal, please see Schroeder & Adesope (2012).

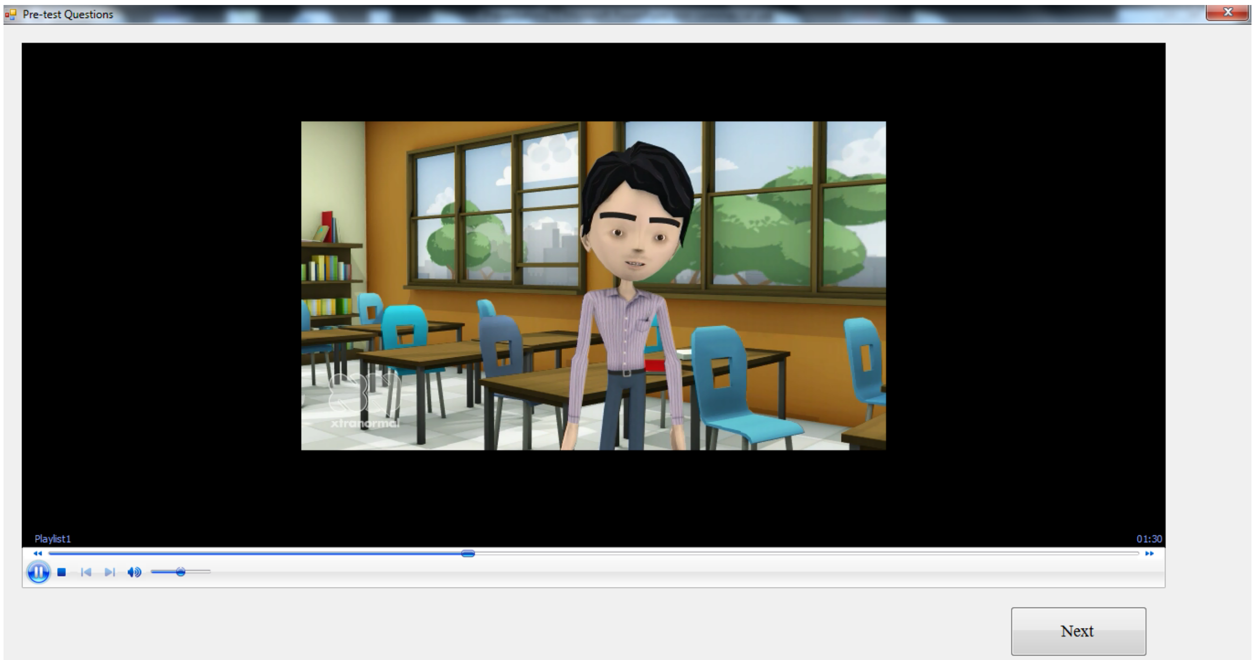

Figure 2. Screenshot from the male peer agent condition which appeared in experiment one and experiment two.

Peer Agents.

Most researchers have used instructor-type agents rather than peer agents in pedagogical agent research (Clarebout et al., 2002). Yet, Kim and Baylor (2006) claimed that "the benefits of peer interaction for learning and motivation in classrooms have been broadly demonstrated through empirical studies" (p. 569). Kim and Wei (2011) suggested that peer or role-model agents may be able to foster affective traits in the learner. This is plausible, as Kim and Baylor suggested that a peer agent could facilitate motivational and learning outcomes by acting as a social model. For instance, a peer agent has been used to foster the learner's attraction to an unpopular knowledge domain (Kim & Wei, 2011).

An ongoing issue in pedagogical agent research is that learners may perceive the agents as "more functional and more intelligent than they actually were" (Kim & Baylor, 2006, p. 573). This could be problematic for learners working with non-intelligent agents which cannot provide individual feedback. If the learner gets frustrated by the instructional monologue or the lack of interaction, it may lead to decreased engagement in the learning process. However, Kim and Baylor (2006) claimed that people derive more confidence from observing peers complete tasks than adults. Perhaps utilizing a peer agent can help deter the aforementioned problem by fostering other affective traits in the learner.

C. *Demographic Questionnaire.*

The demographic questionnaire consisted of eight questions which addressed the student's age, gender, ethnicity, and previous experiences with multimedia and multimedia learning theory.

D. Computer-efficacy Scale.

The learners' computer-efficacy was measured though the use of an adapted version of Compeau and Higgins (1995) computer self-efficacy scale. The scale consisted of 10 questions, answered through an 11 point Likert scale where 0 is "No", 1 is "Not at all confident" and 10 is "Totally confident". In the past, this scale has been found to be reliable with internal consistency reliability measures exceeding .80 (Compeau & Higgins, 1995). In this study, the scale's internal consistency reliability was found to be $\alpha = .92$.

Pre-test. The pre-test consisted of three free response questions concerning multimedia learning theory. The pre-test questions offered a maximum score of 14 points. For the first question, the learners earned one point for correctly identifying or describing each of the following ideas: working memory, long-term memory, schema, germane cognitive load, intrinsic cognitive load, and extraneous cognitive load, for a total of 12 possible points. For the second question, the participants earned one point for correctly describing the split-attention principle, and for the third question the participants earned one point for correctly describing the modality principle. Free response questions were used instead of multiple-choice questions in order to investigate if the participants had any prior knowledge about the learning materials while minimizing any error due to guessing.

Post-test. Three different types of questions were used to measure cognitive outcomes. After viewing the instructional video, participants first completed one free recall question. The question asked the learner to write down everything they could remember from the instructional video. A maximum of 18 points were possible for the free response question. Points were distributed for correctly identifying (1 point) and describing (1 point) the following concepts: germane cognitive load, schema, extraneous cognitive load, intrinsic cognitive load, cognitive load theory, long term memory, short term memory, the modality principle, and the split-attention principle.

Participants then completed thirty multiple choice questions. Each correct answer was worth one point. The questions were designed to test the learner's recollection of specific terms or ideas, as well as apply their knowledge to a hypothetical situation. The multiple choice questions internal consistency reliability was found to be $\alpha = .71$.

The final cognitive outcome test the participants completed was a free response transfer question. The question asked them to design a lesson plan utilizing cognitive load theory, the split-attention principle, and the modality principle. Scoring was identical to the scoring for the free response question.

Affective outcome scores were measured through the Agent Persona Instrument (Ryu & Baylor, 2005). The Agent Persona Instrument was designed to measure a learner's perceptions of the agent. Specifically, the instrument had 10 items which address how well the agent facilitated learning ($\alpha = .94$), five items which addressed how credible the agent was ($\alpha = .92$), five items which addressed how human-like the agent was (α = .87), and five items which addressed how engaging the agent was (α = .86) (Ryu & Baylor, 2005). Participants utilized a five point Likert scale, where 1 is "Strongly disagree" and 5 is "Strongly Agree" to respond to each question. In this study, the scale's internal consistency reliability was found to be α = .94 for facilitated learning, α = .87 for credibility, α = .92 for human-like, and α = .91 for engaging.

E. Procedure.

We solicited volunteers from classes that were geared toward preparing aspiring teachers to obtain their teaching certification. On the day of the experiment, volunteers were brought into a classroom which contained 30 identical Dell computers with 19 inch screens. Each participant was given a set of headphones. The screen resolution was set to 1280x1024, the university's default setting.

When the participants entered the classroom, they received a piece of paper with their name and user ID on it. The experiment was then introduced to the participants, and they were given the opportunity not to participate if they chose to opt-out. The participants then completed the experiment which took about 35 minutes to complete.

IV. Results and Discussion.

The purpose of this study was to compare the effects of learning with either a pedagogical agent or a low verbal redundancy control condition on learner's cognitive and affective outcome scores. Further, we hoped to minimize any possible error by evaluating any possible influence of the participants' computer-efficacy. Next, we delineate the results of the study in relation to each research question and situate the results in extant research.

Research Question One: How does incorporating a pedagogical agent affect learners' free recall, multiple choice, and transfer scores in a LASP learning environment compared to a low verbal redundancy condition?

Examination of the graphs of the learner's free recall scores, multiple choice scores, and transfer test scores showed that the data was normally distributed (Tabachnick & Fidell, 2013). Table 1 shows the means and standard deviations of the data.

Table 1. Results of cognitive measures for experiment one.

	Control (n = 38)		Agent (n = 41)	
	Mean	*SD*	*Mean*	*SD*
Pre-test	0.37	0.71	0.59	0.84
Free Recall	6.95	3.52	5.54	3.33
Multiple Choice	16.92	4.32	17.37	4.47
Transfer	3.39	2.55	3.54	2.47

Maximum possible scores: Pre-test: 14, Free Recall: 18, Multiple Choice: 30, Transfer: 18.

Multivariate analysis of variance (MANOVA) was conducted with the control condition and the agent condition as the fixed factor (i.e., independent variable) and the free recall, multiple choice, and transfer tests as the dependent variables. Box's $M = 3.135$ ($p>.05$), satisfied the assumption of homogeneity within the covariance matrices. Levene's tests revealed p values greater than .05, indicating that there was homogeneity within the error variances within the sample.

The MANOVA revealed that there were no statistically significant differences between groups on any of the cognitive outcome measures (Wilks' $\lambda = .916$, $F(3, 75) = 2.281$, $p > .05$). Even though three measures of learning were used, these results mirror the findings of Baylor and Ryu's (2003) study, as well as other pedagogical agent literature (for a review, see Heidig & Clarebout, 2011). These findings were somewhat surprising, as researchers have argued that contextually-relevant pedagogical agents may be more effective for learning than non-relevant agents such as the Genie used in many studies (Veletsianos, 2007). However the data show that a contextually-relevant, peer pedagogical agent's presence does not equate to increased learning outcome scores in a LASP learning environment.

These results provide important implications for multimedia learning theory. For example, the results show partial support for the presence principle. Even though there were no significant differences between the group which learned with the agent and the one which did not, it is important to note that this does not mean that the agent group was outperformed. Accordingly, it is plausible that the agent was neither distracting nor deleterious for learning compared to the non-agent group.

Our results do not support social agency theory. In previous research, social agency theory has been supported where gestures have been found to be helpful for learning or understanding (Hostetter, 2011; Moreno, Reislein, & Ozogul, 2010). However, in a LASP learning environment the inclusion of gestures did not provide any significant advantage for learning. We posit that this may have occurred because the gestures were not designed to be a salient part of the learning process. In Moreno et al.'s (2010) study, the agent used gestures to indicate which portion of the screen the learner should look at. Alternatively, in our study the gestures were added in an effort to increase the agent's deictic believability (Lester, Voerman, Towns, & Callaway, 1999). In the future, researchers should more thoroughly explore the use of gestures in relation to their purpose. Our results cause us to question if there is a maximum amount of social cues that a human processes when initiating the social conversation schema. Perhaps, as the presence principle suggests, only the verbal social cues rather than the visual social cues are necessary?

Yet, perhaps the most interesting contribution to theory from these results are those in regards to cognitive load theory. Some have argued that pedagogical agents may increase the extraneous cognitive load of the learning environment (Clark & Choi, 2007). Undoubtedly these scholars expressed a valid concern. It is plausible that agents which were not thoughtfully designed and implemented could cause extraneous cognitive load. For instance, Moreno (2005) suggested that the limited nature of the working memory may inhibit learning with a highly animated pedagogical agent. However, the results of this study show no difference in learning between groups, even though the agent was highly visible and animated. Accordingly, the agent's presence did not cause extraneous cognitive load. Despite these results, a few questions remain. For instance, did the agent create extraneous cognitive load at first, but then the load was lessened with time as Sweller (2005) suggests? Was the agent simply ignored (Moreno, 2005) because its gestures were not salient to the learning process? One final consideration is that perhaps our results are more reflective of the LASP pacing than the agent or non-agent conditions themselves. Regardless, one certainty is that future research has many fascinating directions to explore.

Research Question Two: How does incorporating a pedagogical agent affect a learner's perceptions of a LASP learning environment compared to a low-redundancy condition?

First, we examined a graphical representation of the data for the facilitated learning, credible, human-like, and engaging scales and compared them to a normal distribution (Tabachnick & Fidell, 2013). The examination showed that the data were normally distributed. The means and standard deviations of the data is presented by group and organized by scale in Table 2.

Table 2. Results of affective measures for experiment one.

	Control (n = 38)		Agent (n = 41)	
	Mean	SD	Mean	SD
Facilitated Learning	26.34	9.06	27.02	8.73
Credible	15.71	4.72	17.05	3.91
Human-Like	9.26	4.45	11.32	4.17
Engaging	10.26	4.29	11.80	4.32

Maximum possible scores: Facilitated Learning: 50, Credible: 25, Human-Like: 25, Engaging: 25.

MANOVA was conducted and the assumptions of homogeneity of covariance matrices (Box's $M = 10.561$, $p > .05$) and homogeneity of error variances (Levene's tests = $p > .05$) were satisfied. The MANOVA revealed no significant differences between groups in any of the affective measures (Wilks' $\lambda = .907$, $F(4, 74) = 1.907$, $p > .05$). Accordingly, the results show that the pedagogical agent did not enhance participants' affective response more effectively than the low verbal redundancy condition.

Our findings do not align with Baylor and Ryu's (2003) study, where the animated pedagogical agent was found to be significantly more engaging (d=.46), person-like (d=.47), and instructor-like (d=.86) than the non-agent condition. Yet, there are many plausible rationales as to why these differences may have occurred. For example, the instrument used in this study had both validity evidence for its use, as well as much higher reliability scores than the ones used in Baylor and Ryu's work. The internal consistency reliability of the scales in this study were exceeding α=.87 for all measures, while the scales used in Baylor and Ryu's study ranged from α=.68 to α=.74. Perhaps the psychometric differences between Baylor and Ryu's work and this study explain the different results?

It is also plausible that the pacing of the learning environment may have influenced the results of this study. For example, this study utilized a LASP learning environment, while the Baylor and Ryu's (2003) study appears to have used a learner-paced environment. The differences between the two learning environments should not be understated. For example, learner-paced environments require the learner to physically click on a button to bring them to the next segment of instruction. Due to this, the learner must be engaged with the learning environment at some level to even proceed through the learning materials. Alternatively, LASP learning environments merely give the learner the option to rewind, pause, or fast-forward. If the learner does not click on any of those buttons, the pedagogical agent provides an instructional monologue at a set speed from start to finish. Accordingly, it is possible in a LASP environment for a learner to proceed through the instructional materials in their entirety without ever engaging with the materials. Perhaps the increased interaction between the learner and the pedagogical agent in the learner-paced environment provides an affective advantage over the LASP environment? Future research can explore this question.

Our results indicate that the inclusion of a pedagogical agent did not lead to an increase in the learners' perceptive ratings of the system. In the past, researchers have found that pedagogical agents were easier to use and more enjoyable than the non-agent condition (Moundridou & Virvou, 2002), and that agents may be an effective option to increase a learner's affective response to the system (Kim & Wei, 2011). However, the differences between the agents used in previous research and those used in this study deserve close consideration. For instance, one study used artificially intelligent agents provided individualized instruction (Moundridou & Virvou, 2002), while this study used agents which could only provide an instructional monologue. We question if the use of individual responses by the agent through artificial intelligence is a key feature to ascertain improved affective responses from the learner.

Research Question Three: How does a learner's computer-efficacy influence cognitive and affective outcomes when learning with a pedagogical agent compared to a low-redundancy condition?

We first used an independent samples *t*-test to compare the mean scores of the groups on their self-rated computer-efficacy. The *t*-test revealed that there was no statistically significant difference between groups ($t = -.68$, $df = 77$, $p > .05$). As such, computer-efficacy did not produce a source of error in either the cognitive or affective outcomes in our sample.

Limitations. This study had two primary limitations, the voice which the agent used, and the confounding variables. The agent's voice was created using Xtranormal's (2012) speech generator. While we selected an American male voice to be paired with the agent, the voice was clearly created by a computer. In other words, the voice was a bit choppy, and the speech patterns did not flow as well as a native English speakers' might have. Accordingly, the computer generated voice may have impacted the learner's engagement with the learning material. For instance, a few participants commented on the quality of the agent's voice in the transfer or free recall questions, even though they were not prompted to do so. As such, is it plausible that a recorded, human voice may have been more effective for learning, as has been shown in other multimedia studies (Atkinson, Mayer, & Merrill, 2005; Harrison & Atkinson, 2009; Mayer, 2005; Mayer, Sabko, & Mauntone, 2003). In the future, researchers should compare the effects on learning and perception of an agent which uses computer generated speech compared to one which uses recorded human voices in a LASP environment.

As stated, confounding variables may have been present in this study as identified in previous research (Clark & Choi, 2005). In other words, the conditions in this study differed by more than only the agent's presence on the screen. For instance, the agent condition contained a virtual classroom as the background and the agent utilized gestures, while the control condition had neither of these features. Accordingly, if significant differences were found between groups it would have been impossible to relate learning or perceptive impacts to only the agent's presence alone. While this was not an important factor in this study, which sought to investigate the effectiveness of two different types of learning environment, it may be a factor in future research.

V. Conclusion.

At first glance, non-significant differences between groups may seem to be inconsequential. However, for the purposes of this study these findings are, in fact, very powerful. For instance, this study has shown that a pedagogical agent and a low verbal redundancy environment, when paired with LASP instruction, produced similar learning benefits. Previous research would not have predicted this outcome, as pedagogical agents have only been found to have a small effect compared to non-agent conditions (Schroeder, Adesope, & Barouch Gilbert, 2013), while low verbal redundancy environments have produced high effect sizes compared to voice only conditions (Adesope & Nesbit, 2012).

Findings of this study hold particular importance for teacher educators. Research has shown that instructors can act as role models by demonstrating how technology can be used effectively in the classroom (Tondeur et al., 2011). Accordingly, when looking for novel ways to integrate technology, an instructor may use pedagogical agents. For instance, it is tempting to incorporate a pedagogical agent into a learning environment because of their versatility and the novelty they provide. However, incorporating an agent may require more resources to develop and implement than a low verbal redundancy environment. This being the case, teacher educators should feel confident in their ability to use either option within a LASP learning environment, as they produced similar results in this study.

This study also holds importance for those who teach educational technology courses. For instance, an educational technology instructor's mission may be to teach pre-service teachers how to use technology effectively in their classroom. Hence, finding accessible technologies which students will find interesting is likely a key challenge faced. In this study, Xtranormal (2012) provided a very simple, easy to use software for the creation of pedagogical agents. While Xtranormal is no longer an active website, numerous other similar software packages exist such as GoAnimate (GoAnimate, 2013), SitePal (Oddcast Inc., 2013a) and Voki (Oddcast Inc., 2013b). As an educational technology instructor seeks out the most advanced, accessible technologies to teach their pre-service teachers, accessible pedagogical agent software may find its way into the coursework.

In sum, this study has raised more questions than it has answered. For instance, did the pedagogical agent perform better in a LASP environment than in previous studies, or was the low verbal redundancy environment simply not as effective? Future research should explore this question by also utilizing a voice only control group. Other questions raised by this study include, how did the participants' cognitive load influence their learning and perception scores? Did the pacing of the study cause more or less cognitive load for students than a traditional learner-paced or system-paced environment? Would participants with differing levels of computer-efficacy find different results from working with peer agents in a LASP learning environment? Future research can examine these questions in depth.

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