EXPLORING PEDAGOGICAL AGENT USE WITHIN LEARNER-ATTENUATED SYSTEM-PACED LEARNING ENVIRONMENTS

By

NOAH LEE SCHROEDER

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WASHINGTON STATE UNIVERSITY
Department of Educational Leadership and Counseling Psychology

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To the Faculty of Washington State University:

The members of the Committee appointed to examine the dissertation of Noah Lee Schroeder find it satisfactory and recommend that it be accepted.

_______________________________________
Olusola O. Adesope, Ph.D., Chair

_______________________________________
Brian French, Ph.D.

_______________________________________
Tariq Akmal, Ph.D.
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Abstract

by Noah L. Schroeder, Ph.D.
Washington State University
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Chair: Olusola O. Adesope

Educational technology is influencing the paradigms of both K-12 and post-secondary education in the United States. While some teachers may still give lectures in a classroom environment, we are now seeing the development and increasing popularity of online schooling. As educators attempt to meet the challenges of teaching with technology, they must choose which educational tools they will employ. Pedagogical agents represent one such tool. Pedagogical agents are on-screen characters which have been found to facilitate learning in some situations. The purpose of this dissertation was to explore pedagogical agents use in a learner-attenuated system-paced (LASP) learning environment. LASP learning environments differ from other types of multimedia learning systems because they allow the user to fast-forward, pause, or rewind, while presenting all of the information in one streaming video rather than numerous segments. The first experiment explored the differences in cognitive and affective outcomes between learning with a low verbal redundancy environment, which provided narration and concurrent on-screen keywords, with a contextually-relevant peer pedagogical agent condition. The second experiment explored the differences between cognitive and affective outcomes when learning with either a male or female pedagogical agent in a LASP learning environment. No significant differences were found in either experiment for any of the cognitive or affective outcomes. The findings indicated that pedagogical agents may be just as effective for learning
and fostering a learner’s affect as a low verbal redundancy environment. The findings also indicated that a male pedagogical agent is equally effective for both learning and fostering a learner’s affect as a female pedagogical agent. Theoretical and practical implications of the findings are discussed, as are promising future research directions.
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CHAPTER ONE

INTRODUCTION

The drive towards technology integration and online learning in schools has led some scholars to claim that “the present vision…imagines technology’s infusion into all aspects of the educational system” (Shapley, Sheehan, Maloney, & Caranikas-Walker, 2011, p. 299). Other scholars have expanded this notion by claiming that we can no longer avoid technology integration in the classroom. Rather, we must figure out how to most effectively use technology to teach our students (Barreto & Orey, 2013). An example of educational technology’s infusion in the K-12 classroom can be seen through the lens of online learning. Online learning has become commonplace among K-12 schools (Watson, 2005). During the 2007-2008 school year, there were more than one million K-12 students enrolled in online courses (Picciano & Seaman, 2009), and by 2009, there was at least one virtual school in 29 different states (Hightower, 2009). Clearly, teaching and learning with technology is taking hold within the United States’ K-12 educational system. This immersion in learning technologies has challenged many teachers because it changes the way we engage one another, communicate, and learn (Archembault & Crippen, 2009).

Researchers and educators alike are now being faced with the challenges of engaging and motivating students to learn in multimedia learning environments. Yet, before one can approach this issue, a more basic question must be answered: how will I present the learning material to students? Educators have a vast array of technology tools available to them, such as intelligent tutoring systems and online learning management systems. One such tool is the pedagogical agent. Pedagogical agents have been found to have small, positive effects on learning compared to non-agent environments (Schroeder, Adesope, & Barouch Gilbert, in press). However, their
use is still relatively new in educational contexts and the literature surrounding their effectiveness is still evolving.

The first experiment in this dissertation explores the cognitive (learning) and affective (perceptive) effects of learning with a pedagogical agent compared to a low verbal redundancy, non-agent learning environment. For the purposes of this dissertation, a low verbal redundancy condition provides narration while keywords are concurrently displayed on the screen (Adesope & Nesbit, 2012). The experiment also explores if a learners’ computer-efficacy influences the relationship between the group and the learner’s cognitive and affective outcomes. The second experiment in this dissertation examines the cognitive and affective outcomes of manipulating the agent’s gender, as well if a learners’ computer-efficacy influences this relationship. Chapter One presents the importance of these two experiments. Chapter Two summarizes the theories and literature which guided the experimental designs. Chapter Three describes the methods used for the design, data-collection, and data analysis of both experiments. Chapter Four provides the results of each experiment. Finally, Chapter Five illuminates the theoretical and practical implications of each experiment

**Definitions**

For the purposes of this dissertation, a pedagogical agent is a character which appears in a multimedia learning environment to facilitate learning (Moreno, 2005; Schroeder et al., in press). Pedagogical agents are not necessarily powered by artificial intelligence (for reviews of intelligent tutoring systems, see Ma, Adesope, & Nesbit, 2011 and VanLehn, 2011); however, if one wishes to create a conversational agent which can answer student questions (Veletsianos, Miller, & Doering, 2009), an intelligent tutoring system or some other form of artificial
intelligence are necessary. As such, pedagogical agents are differentiated from conversational agents because they cannot answer student questions, but rather provide an instructional monologue (Veletsianos, Miller, & Doering, 2009).

Another important term, the pacing of the system, refers to the speed and manner in which learning materials are presented to the learner. Within the pedagogical agent literature, there have been two primary types of pacing utilized by researchers: (a) system-pacing and (b) learner-pacing. System-paced learning environments typically display a video clip to the learner. When using system-paced instruction, the learner cannot pause, fast-forward, rewind, or restart the clip. The learner is simply shown the clip in its entirety, perhaps more than once. Inherently, some learners may encounter difficulties with system-paced instruction. If the agent speaks too quickly, presents too many ideas, or uses too much complex terminology, the learner may get lost or confused. Van Merriënboer and Kester (2005) claimed that system-paced instruction, such as streaming videos, do not allow learners the necessary time to deeply process the information they are learning. Thus, learners may miss portions of the presentation while they try to assimilate novel information with their prior knowledge.

Alternatively, learner-paced systems have buttons which clearly indicate that the learner can skip forward or move backwards through predetermined segments of instruction (e.g., Dunsworth & Atkinson, 2007; Kizilkaya & Askar, 2008) as suggested by Mayer (2005b). Yet, some technology tools available to teachers do not provide such a dichotomy in the learning environments they can produce. For example, Xtranormal (2012) can be used to create learning environments which contain pedagogical agents. The videos produced by Xtranormal have a pause button and allow the learners to fast-forward and rewind as they please. Simultaneously, the learner does not control the pace of the instructional materials because the agent speaks at a
pre-determined speed, and goes through the instructional material from start to finish. In other words, the presentation is not segmented, but rather one contiguous, streaming video. As such, the type of pacing produced by Xtranormal is more appropriately referred to as learner-attenuated system-paced (LASP) instruction. In other words, LASP learning environments are a hybrid of system- and learner-paced environments. They allow the learner to “pause and better reflect on the new information in order to couple it to already existing cognitive structures” (van Merriënboer & Kester, 2005, p. 83), while retaining the non-segmented characteristics of the system-paced environment.

**Importance of the Research**

Pedagogical agents have been researched for more than a decade. Moreno (2005) reported that the literature grew from research around software agents. Software agents differ from pedagogical agents because they operate “behind the scenes” (Moreno, 2005, p. 508). In other words, they do not physically appear on the screen as a pedagogical agent does (Moreno, 2005). Historically, a problem for teachers who wanted to implement pedagogical agents was their cost. In addition, until recently, incorporating a pedagogical agent required complex software programs and could be very time consuming. Such constraints on resources have led some researchers to argue that pedagogical agents may not be cost-effective (Clark & Choi, 2005; 2007; Choi & Clark, 2006). Yet, technology continues to become more affordable (Barreto & Orey, 2013) and programs such as Xtranormal (2012), which allow a pedagogical agent to be integrated into a learning environment at very little or no cost, making their use more feasible.

It is important to note that cost-effectiveness is not the only point of debate surrounding pedagogical agents, nor is it of utmost importance to many educational researchers. Rather, pedagogical agents’ impacts on cognitive and affective outcomes are of continuing interest (e.g.
Domagk, 2010; Gulz, 2004; Heidig & Clarebout, 2011; Kim & Ryu, 2003, Schroeder, et al., in press; Veletsianos 2010; 2012). For example, researchers have expressed concern that pedagogical agents may cause learners to focus on parts of the presentation that are not essential to the learning process (Clark & Choi, 2007). As such, pedagogical agents may distract the learner from the learning materials (Moreno, 2005; van Mulken, André, & Muller, 1998), which can be deleterious to cognitive outcomes.

Recently, a number of review papers have been published attempting to summarize pedagogical agent studies. A meta-analysis indicated that pedagogical agents can have small, positive effects on learning (Schroeder et al., in press). Yet, a systematic review found that most experimental studies did not produce statistically significant effects on learning outcomes (Heidig & Clarebout, 2011). Overall, it has been observed that studies investigating learning with pedagogical agents have produced mixed results (Domagk, 2010). Despite the mixed findings in regards to learning outcomes, researchers have also found that if given a choice, students chose to learn with a pedagogical agent on the screen rather than without an agent present (Moreno & Flowerday, 2006). As such, it is plausible that pedagogical agents may continue to be incorporated within learning environments as teachers seek ways to better teach, engage, and motivate students with electronic learning materials.

**Experiment One**

The purpose of this dissertation is to investigate a pedagogical agent’s implementation and gender on affective and cognitive outcomes, as well as to explore if a learner’s computer-efficacy influences these relationships within a LASP learning environment. The first experiment can be understood as an extension of Baylor and Ryu’s (2003) study. Baylor and Ryu
examined the affective and cognitive effects of incorporating a pedagogical agent and an animated pedagogical agent compared to a non-agent learning environment. Their results indicated that compared to the non-agent condition, the animated pedagogical agent was found to be significantly more engaging ($d=0.46, p<.05$) and instructor-like ($d=0.86, p<.05$). Additionally, the conditions which included an agent were found to be more credible than the non-agent condition ($d=0.47, p<.05$). However, no significant differences were found when examining learning outcomes between any of the three conditions.

There were many reasons to justify the expansion of Baylor and Ryu’s (2003) study. First and foremost is the advancement in and proliferation of instructional technology over the past decade. Using Xtranormal (2012), an Internet-based software, the pedagogical agents utilized in the following experiments are more anthropomorphized and contextually-relevant than the previous work, thus addressing a call for research (Veletsianos, 2007). Veletsianos has argued that using contextually-relevant agents may foster learning more-so than the Microsoft agent Genie which was used in Baylor and Ryu’s (2003) study. In addition to the use of more contextually-relevant agents, the agents also appeared as peers rather than instructors, which addressed Baylor and Ryu’s call for replicating their study using different agents. Another factor was the control system used in Baylor and Ryu’s study, which utilized fully redundant text and narration. In other words, the control condition provided narration as well as verbatim on-screen text. For this study, the experiment investigated whether the use of a low verbal redundancy control condition (narration with keywords displayed on the screen as text), which has been found to be more beneficial than a fully redundant text and narration condition (Adesope & Nesbit, 2012), influences the affective and cognitive outcomes compared to a male peer pedagogical agent.
Another limitation of the Baylor and Ryu (2003) study was their measurement techniques. Since the publication of Baylor and Ryu’s work, an agent persona scale has been developed and internal structure validity evidence for the scale has been provided through confirmatory factor analysis (Ryu & Baylor, 2005). Using this scale may provide more accurate insights into the way the agent is perceived than the questionnaires used in Baylor and Ryu’s study. Similarly, Baylor and Ryu only used one measure of learning, a performance assessment. For this study, three different learning assessments (free recall, multiple choice, and transfer) were used in an effort to isolate the learning skills of retaining information and transferring it to a practical application. Finally, the study was further expanded by measuring the learner’s computer-efficacy in order to see if it influences the relationship between the condition they learned with, their perceptions of the learning environment, and their learning outcome scores. In sum, expanding the Baylor and Ryu (2003) study was both called for in recent research and necessary in order to gain insights into the effectiveness of pedagogical agents within a LASP learning environment.

**Experiment Two**

The second experiment completed in this dissertation examined how a learner’s computer-efficacy can influence the relationship between their perceptions of and learning with either a male or female pedagogical agent within a LASP learning environment. This idea stemmed from research findings which suggest that pedagogical agents are stereotyped by their appearance (Moreno et al., 2002) and that learners may draw conclusions based upon the agent’s appearance before instruction takes place (Veletsianos, Miller, & Doering, 2009).

Researchers have, to a limited extent, examined how perceptions and learning can be varied by using either a male or female pedagogical agent (e.g. Baylor & Kim, 2009; Kim,
Baylor, & Shen, 2007; Moreno et al., 2002). Moreno et al. found that male agents facilitated learning outcomes more effectively than female agents and that the gender of the agent caused the learner to invoke stereotypes. Kim, Baylor, and Shen found that a male pedagogical agent tended to be perceived more positively than female agents, that male agents were rated more interesting, and that male agents fostered more beneficial learning outcomes than female agents; however, these results are not readily generalizable in regard to learning outcomes because significant differences were not found in their application question and their second experiment did not find any significant learning differences between genders. Further work by Baylor and Kim (2009) indicated that female pedagogical agents led to an increase in learner self-efficacy. However, the agent’s gender did not produce significant differences in learning outcomes (Baylor & Kim, 2009).

In sum, research has shown that pedagogical agents are stereotyped by their appearance, but these stereotypes do not necessarily affect learning outcomes. The above-mentioned studies are limited by the fact that they all used pedagogical agents which appeared older than the learner. Due to advances in instructional technology, the agents also appeared more pixelated and less realistic than current software can provide. Thus, the second experiment extended previous research by (a) using more advanced technology which produced anthropomorphized, contextually-relevant peer agents, (b) investigating the influence of a learner’s computer-efficacy on their perceptions of and learning with either a male or female pedagogical agent, (c) using an instrument which has validity evidence to support its use to measure pedagogical agent persona, (d) using three different measures of learning outcomes, and (e) using a LASP learning environment.
Research Questions

In order to approach the issues noted above, this dissertation investigated the following research questions:

Experiment 1: An empirical test of the presence principle within a LASP learning environment.

1) How does incorporating a pedagogical agent affect a learner’s 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 a learner’s perceptions of a LASP learning environment compared to a low-redundancy condition?
3) How does a learner’s computer-efficacy influence the relationship between cognitive and affective outcomes and whether they learned with a pedagogical agent or a low verbal redundancy condition?

Experiment 2: Exploring the impact of agent gender within a LASP learning environment.

1) How does learning with a male pedagogical agent affect the learner’s free recall, multiple choice, and transfer scores compared to learning with a female agent?
2) How does learning with a male pedagogical agent affect the learner’s perception of the agent compared to a female agent?
3) How does the learner’s computer-efficacy influence the relationship between cognitive and affective outcomes when learning from pedagogical agents of different genders?
CHAPTER TWO

LITERATURE REVIEW

This dissertation investigates a pedagogical agent’s ability to affect learners’ cognitive and affective outcomes, as well as to investigate any influence of the learners’ computer-efficacy. Pedagogical agent research has been based upon theories from many fields including cognitive psychology, educational psychology, human-computer interaction, and information technology. The theories described below served as a foundation for the design of the experiments included in this dissertation. Before the theories are discussed, the next section examines the use of pedagogical agents within multimedia learning environments.

Potential Uses of Pedagogical Agents

Researchers have suggested 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). In other words, although pedagogical agents can play many roles in a multimedia learning environment, their design and implementation must be thoughtfully guided to enhance learning. Clarebout, Elen, Johnson, and Shaw (2002) suggested that pedagogical agents can facilitate supplanting, demonstrating, coaching, modeling, and scaffolding in multimedia learning environments. As such, pedagogical agents can play a variety of roles in the learning environment and therefore have the potential to be utilized in numerous learning tasks regardless of the domain of instruction. In the past, pedagogical agents were used to teach students about subjects such as the human heart (Dunsworth & Atkinson, 2007), botany (Moreno, Mayer, Spires, & Lester, 2001), mathematics (Atkinson, 2002), and astronomy.
(Kızılkaya & Askar, 2008). In the future, pedagogical agents could potentially be used to demonstrate how to dissect a frog, or act as a coach to guide learners through improving their writing skills. These more advanced pedagogical agents may begin to appear in the literature as the programs needed for their design and implementation become available to a wider audience. As the implementation of advanced pedagogical agents becomes easier, the role the pedagogical agent can play in the learning environment will be limited only by the software’s abilities and by the instructor’s imagination.

**Presence Principle**

Despite their varied uses, the notion of using pedagogical agents has been routinely challenged (Choi & Clark, 2006; Clark & Choi, 2005; Mayer, Dow, & Mayer, 2003). While some argue against pedagogical agents cost-effectiveness (Choi & Clark, 2006) or claim that they make the learning environment too complex (Choi & Clark, 2007), others have found that the agents do not seem to create significant differences in learning outcomes (Heidig & Clarebout, 2011; Moreno, Mayer, Lester, & Spires, 2001). Research by Mayer, Dow, and Mayer (2003) concluded that “people do not learn better when an agent is physically present on the screen. Although the agent’s voice is important for improving learning, the agent’s physical image is not” (p. 811). Mayer et al. named this phenomenon the presence principle, and suggested that the agent’s image is a “seductive detail” (p.811). Seductive details are non-essential pieces of information for the learning process (Mayer et al., 2003). Thus, the agent, as a seductive detail, is either being ignored (Moreno, 2005) or presents a source of distraction during the learning task (Mayer et al., 2003; van Mulken, André, and Muller, 1998). Heidig and Clarebout’s (2011) review further substantiated this claim, finding that the majority of pedagogical agent studies did not produce any significant differences in learning or motivational
measures. Yet, most of the research to date has utilized learner-paced learning environments (Schroeder et al., in press). As such, the first experiment in this dissertation aims to expand the literature by examining if a pedagogical agent’s appearance in a LASP learning environment will facilitate the learners’ cognitive and affective outcomes compared to a low verbal redundancy, voice and text condition.

Despite the evidence suggesting that pedagogical agents are unnecessary for learning, controversy still exists as researchers find mixed results. 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 directly refutes notions that the agent may be ignored (Moreno, 2005). Other researchers have suggested pedagogical agents may provide motivational effects in some situations (Gulz, 2004; van Mulken, André, and Muller, 1998). Furthermore, Moreno (2005) noted that if the motivational benefits outweigh the deleterious effects of distraction, learning will be enhanced. Finally, a recent meta-analysis found that including a pedagogical agent within the learning environment provides small, yet positive effects on learning outcomes (Schroeder et al., in press).

In sum, one is left to question whether a pedagogical agent’s visual appearance within the learning environment benefits learning. 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. The first experiment in this dissertation seeks to examine if a pedagogical agent’s presence in a LASP learning environment affects learners’ cognitive or affective outcome scores.
Social Agency Theory

It is plausible that since pedagogical agents are seen as conversational partners (Louwerse, Graesser, McNamara, & Lu, 2008) they can foster learning by increasing the social agency of the learning environment. Moreno et al. (2001) found that “students learn a computer-based lesson more deeply when it is presented in a social agency environment than when it is presented as a text and graphics source” (p. 209). Social agency is fostered through social cues in the learning environment, and thus “can prime the social conversation schema in learners” (Mayer, Sobko, & Mautone, 2003, p. 419). These social conversation schemas enact human-human social interaction rules such as selecting information, consolidating it, and incorporating it with prior knowledge (Mayer, Sabko, and Mautone, 2003). Another way of understanding social agency theory is that it hinges on creating the illusion of a social interaction between the learner and the computer. Veletsianos, Miller, and Doering (2009) expanded this definition by suggesting that human-computer interaction can likely be approximated to social human-human interactions.

Kim, Baylor, and Shen (2007) claimed that pedagogical agents were seen as social models and were expected to have a personality, which suggests that pedagogical agents are seen as social partners. As mentioned, eye-tracking research reiterated these findings (Louwerse, et al., 2008). One may infer that social interactions between the computer and the learner can be understood as either instructor-student or student-student conversations. Given that pedagogical agents may be stereotyped by their appearance (Moreno et al., 2002; Veletsianos, 2007), it is also plausible that the social interaction can be manipulated by changing the appearance of the agent, the voice of the agent, the behavior of the agent, and the agent’s speech patterns. Holistically, these aesthetic and behavioral variables can influence the pedagogical agent’s contextual-
relevance, which Veletsianos (2007) argued is critical “because it may influence learners’ attention and perceptions and degree of agent relevance, seriousness, and authenticity” (p. 374), all of which may affect cognitive outcomes.

In the past, many researchers have not used contextually-relevant agents. For example, Choi and Clark (2006) used a Genie to teach English as a Second Language students about English-relative clauses. Their results showed no significant learning differences between the agent group and a group that worked with a voice and arrow program. Veletsianos (2007) argued that this may be due to the lack of consideration for the agent’s aesthetics, as a Genie is not contextually-relevant to learning English-relative clauses. The Choi and Clark study is not unique in using a non-relevant agent. Many studies have used agents which do not appear contextually relevant to the learning task (e.g. Atkinson, 2002; Cheng et al., 2009, Kizilkaya & Askar, 2008; Moreno et al., 2001), which may be a reason for the mixed findings surrounding the usefulness of pedagogical agents’ ability to facilitate learning (Veletsianos, 2007).

In addition to the agent’s appearance, its voice is equally, if not more important for fostering social agency. Multimedia research has suggested that a human voice is more effective for learning than a machine-synthesized voice (Mayer, 2005; Mayer, Sabko, & Mautone, 2003). Furthermore, findings have shown that a human voice of standard accent will facilitate learning more effectively than a non-standard voice (Mayer, 2005; Mayer, Sabko, & Mautone, 2003). Yet, a meta-analysis of pedagogical agent studies found that the type of voice used by the agent did not produce statistically significant effect sizes (Schroeder et al., in press). In other words, learning was not affected to a statistically significant level if the agent communicated through a recorded human voice, computer-generated voice, or computer-edited voice. For the purposes of this study, the voices the agents provided were generated by Xtranormal’s (2012) text-to-speech
The voices used were selected because they were meant to replicate American, human voices.

While the agent’s voice may be important for learning outcomes, 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 (Choi & Clark, 2007). Both of these arguments hinge on cognitive load theory and its associated principles, which are discussed in the next section.

**Cognitive Load Theory**

Cognitive load theory describes the human cognitive process with the assumption that the long-term memory is the central processor and information storage site, while the working memory evaluates new information (Kirschner, Sweller, & Clark, 2006; Sweller, 2005). Theorists have suggested that once information is brought into the working memory from the individual’s sensory processes, the novel information is stored and organized in the long-term memory by structures called schema (Sweller, 2005).

Theorists have also described three disparate types of cognitive load: intrinsic, extraneous, and germane (Paas, Renkl, & Sweller, 2003; Sweller, 2005; 2010). The cognitive load, or mental strain, due to the complexity of the learning materials is known as intrinsic cognitive load (Paas, Renkl, & Sweller, 2003; Sweller, 2005). Intrinsic cognitive load can be variable between students, as it depends on the new information’s interaction with the learner’s prior knowledge (Sweller, 2005; 2010). Extraneous cognitive load occurs as a result of the way the material is presented to the learner rather than the contents of the material (Sweller, 2005;
Finally, germane cognitive load is due to the new information being integrated with the prior knowledge in the schemas (Sweller, 2005).

Essentially, the arguments which claim that pedagogical agents create distraction and make the learning environment too complex suggest that the agents present a source of extraneous cognitive load. These concerns are aligned with the split-attention principle, which states that for optimal learning, learners should not have to split their attention between two different sources of information (Ayers & Sweller, 2005). In the context of pedagogical agents, this would suggest that the agent and a worked-example on the screen simultaneously (e.g. Atkinson, 2002) would lead to deleterious learning outcomes. However, in her review of pedagogical agent studies, Moreno (2005) noted that no studies have shown evidence of the split-attention principles effects. Moreno posited that students process an agent’s image less over time and they become familiar with its presence. This is plausible, as Sweller (2005) claimed that information stored in the long-term memory does not require additional cognitive resources when re-introduced to the learner through the working memory.

Social Cognitive Theory and Computer-Efficacy

Human cognition does not maintain sole responsibility for decision making. Affective states, actions, and environmental factors also interact when an individual makes decisions (Bandura, 1989). Decisions are products of an individual’s perceptions of the environment, intrinsic motivations, and cognition. Social cognitive theory delineates a “triadic reciprocal causation” model of “emergent interactive agency” (Bandura, 1989, p. 1175). Using this model, Bandura suggested that humans are not purely independent of their actions, nor are they entirely agents of external events. Hence, the design features of pedagogical agent-based learning environments are important.
Bandura’s (2001) theories of human agency can be seen as the foundation for the notion of a pedagogical agent. For example, proxy agency suggests that one would rely upon someone with more knowledge, such as an instructor, in order to succeed (Bandura, 2001). These proxy-led situations are the commonplace in pedagogical agent research, where the agent generally acts as a coach or a mentor (Clarebout et al., 2002). Building upon the notions of human agency, the peer agents used in this study are designed to have more relevant knowledge than the learner. Thus, the agent is designed to foster proxy agency.

Personal agency, on the other hand, describes human self-reflectiveness, self-reactiveness, intention, and forethought (Bandura, 2001). Humans will engage challenges they believe they can handle, while avoiding situations they believe they cannot handle (Bandura, 1989). As such, when constructing a learning environment the designer must make sure the display and the information presented is not too daunting for the learner. If the display is too complex, or poorly designed, it may increase the amount of effort the learner must put forth in order to learn. This increase in necessary mental effort may in turn push them away from engaging with the learning material. Personal agency also includes self-efficacy, as self-efficacy (i.e., one’s perceptions about oneself in relation to their ability to complete a task) influences an individual’s behavior, emotions, and thoughts (Bandura, 1982). Research around self-efficacy theory gave rise to the concept of computer-efficacy, or an individual’s confidence in his/her ability to use computers to complete a task (Compeau & Higgins, 1995). A learner’s computer-efficacy is important when examining how she/he uses, works with, and learns from a computer because it can, like self-efficacy, influence his/her thoughts, behaviors, and emotions (Compeau & Higgins, 1995).
Ideally, the features of a learning environment should facilitate the learner’s self-efficacy beliefs. This is important, because if learners feel they are unable to cope with the situation, they may feel distressed and try to escape (Bandura, 1977; 1989). Alternatively, Bandura suggested that when people cope with situations that fall within the bounds of their self-efficacy, negative psychobiological reactions are absent. Since students spend a large portion of time engaged in learning within a classroom environment, it is plausible that a virtual classroom may lead to higher levels of self-efficacy. As such, the pedagogical agents used in this dissertation appeared within a virtual classroom. The learning environment also gave the learners control of the presentation, in that they can fast-forward, pause, or rewind if they feel they know well or misunderstood portions of the instruction. These factors may culminate into a motivational experience for the learner, as pedagogical agents have been posited to facilitate student motivation in some situations (Gulz, 2004; Moreno, 2005; van Mulken et al., 1998).

One remaining question is how will learners’ computer-efficacy influence their cognitive and affective outcomes when learning with pedagogical agents? Based on the aforementioned literature, it is plausible that computer-efficacy may play some role the participants’ cognitive and affective outcomes. For instance, within the present study a learner with low computer-efficacy may find the non-agent condition in experiment one easier to learn with because there is less going on in the learning environment. Alternatively, this same learner may find the agent condition more effective and appealing because it makes the learning environment friendlier or less imposing. The experiments in this dissertation explore the role of computer-efficacy in influencing the relationship between a participant’s cognitive and affective outcomes with the different technology tools (i.e. male agent compared to female agent).
As mentioned earlier, this dissertation investigates how pedagogical agents are perceived by learners. Considering that one goal of this study is to foster proxy agency, how an agent is perceived can potentially be very important to learning outcomes. As such, gender stereotypes may play a central role in learning with pedagogical agents.

**Gender Stereotypes**

The second experiment explores how manipulating the pedagogical agent’s gender in a LASP learning environment can impact social agency, and thereby impact cognitive and affective outcomes. As previously mentioned, researchers have investigated the differential effects of the pedagogical agent’s gender on learning to a limited extent (Baylor & Kim, 2004; Kim, Baylor, & Shen, 2007; Moreno et al., 2002). While affective measures such as the student’s perceptions (Baylor & Kim, 2004) and stereotypes (Moreno et al., 2002) of the pedagogical agents change depending upon the agent’s gender, findings have shown that the agent’s gender only makes minimal differences on cognitive outcomes (Kim, Baylor, & Shen, 2007). Yet, none of these studies have taken place in LASP learning environments.

For the purposes of this study, a gender stereotype is an unconscious thought process that guides expectations of how each gender should look, speak, and behave (Llorente & Morales, 2012; Tantekin Erdin, 2009). These stereotypes influence individuals thoughts, behavior, and rationality (Llorente & Morales, 2012), thus presenting a “very real problem” (Potvin, Hazari, Tai, & Sadler, 2009, p.845) in educational contexts. Researchers have suggested that males are stereotyped as being competent, aggressive, brave, assertive, and good at science, while females are stereotyped as submissive, obedient, shy, emotionally unstable, dependent, and weak (Llorente & Morales, 2012; Tantekin Erdin, 2009). It is not a stretch to imagine how these gender stereotypes in schools could profoundly damage students’ motivation and self-esteem.
(Tantekin Erdin, 2009). Since the United States claims to provide equitable instruction to both female and male students (Davis & Nicaise, 2011), it is plausible that teachers strive to eliminate these stereotypes in schools. But are these stereotypes truly absent in school environments?

Gender stereotypes in school settings can occur from both the teachers and the students, both of which can influence classroom interactions (Madrid & Hughes, 2010). Teachers, for example, may provide differential instruction to females or males because of their own gender, expectations, or lack of awareness (Davis & Nicaise, 2011). Davis and Nicaise suggested that a lack of interaction between students and teachers may negatively affect achievement. Another finding from Davis and Nicaise’s study was that “female teachers had more interactions with male students, and male teachers had more interactions with female students” (Davis & Nicaise, 2011, p. 21). Thus, despite one’s gender as a student, sooner or later the student may encounter a teacher of the same gender, which may decrease the amount of teacher-student interaction.

Examining the student perspective, Madrid and Hughes (2010) found that male teachers were perceived to produce poor results compared to female teachers, while also using an authoritarian teaching style. Meanwhile, female teachers were more accepted by students and thought to provide more student support, thus producing better learning outcomes (Madrid & Hughes, 2010). Potvin et al. (2009) examined student’s gender biases against science teachers and found that even changing disciplines (e.g. chemistry or physics) can influence the resulting biases. Furthermore, researchers have found that a students’ gender can also influence who they perceive to be a good teacher (Jules & Kunick, 1997). Yet, the literature as a whole is not clear whether students feel they learn more from male or female teachers. While Madrid and Hughes suggested that both female and male students believed female teachers were more effective, Davis and Nicaise (2011) found that male students did not believe female teachers were as
knowledgeable as their male counterparts. Perhaps these beliefs can also change depending on students’ educational levels. More research is needed to further explore how student’s gender-stereotype driven expectations vary depending upon their age.

In summary, both the teacher and the student can encounter gender stereotypes in the classroom. The purpose of the second experiment was to eliminate the role of the teacher’s biases. In other words, the pedagogical agents provided verbatim instruction and interaction with both genders of students. As such, the student’s gender stereotypes are isolated for examination without the confounding influence of a human teacher’s presence in the LASP learning environment. Understanding how a student’s gender stereotypes influence learning and perceptions is important in pedagogical agent research because of the agent’s physical appearance on the screen. If the results show that students learn more from a female agent than a male agent, or vice versa, it is a very important implication for future instructional design. For example, if female pedagogical agents are found to be more effective for learning than male agents in a LASP learning environment, and the results are reiterated through future studies, it would be very simple for an instructional designer to use female pedagogical agents to facilitate learning tasks.

**Bridging Theory and Practice**

Researchers have long documented the gap between educational theory and practice (Kessels & Korthagen, 1996; Korthagen & Kessels, 1999; Nuthall, 2004). “We have a gap between theory and practice that hampers both the teacher educator and the student. The task of the teacher educator is to try and bridge it, and, like our student, the teacher educator often fails” (Kessels & Korthagen, 1996, p. 18). For example, it has been claimed that pre-service teacher
programs often fail to prepare their students for the realities of the classroom environment (Goodlad, 1990 as cited by Korthagen & Kessels, 1999). In other words, while a pre-service teacher may know how to use a specific piece of technology, this knowledge alone does not equate to its effective use within the classroom (Ertmer & Ottenbreit-Leftwich, 2010). For the purposes of this dissertation, the terms aspiring teacher and pre-service teacher will be used interchangeably.

The gap between educational theory and practice within teacher education is difficult to approach because it is not a static phenomenon with a prescribed solution. Rather, the gap represents a dynamic interaction of constructs which create the notion of “best practices” in teaching. However, identifying these fundamental issues is problematic when delineating what teachers must understand in order to teach successfully (Nuthall, 2004). Nuthall suggested that the challenge of identifying what teachers need to be taught can be deflected by understanding their day to day activities in the classroom. In other words, to bridge the theory-practice gap, we must consistently reassess how teachers plan and manage their lives within classrooms. Recently, researchers have claimed that “effective teaching requires technology use” (Ertmer & Ottenbreit-Leftwich, 2010, p. 256) to create relevance in “the world of the digital native” (Lawrence, 2009, p. 1487).

While “teacher education programs may have a substantial effect on teacher development” (Tantekin Erdin, 2009, p.410), researchers have found that there is generally only one educational technology course that prepares pre-service teachers to use technology in their teacher education programs (Lambert & Gong, 2010). However, researchers have begun to see changes in the outcomes of teacher education technology studies. Despite the challenges presented by preparing teachers to use technology in the classroom (Lambert & Gong, 2010), a
review of the literature found that we are now making strides towards aligning theory and practice in our teacher education programs (Tondeur et al., 2011).

When reflecting on the recent research literature about the theory-practice gap, one may wonder what is happening in classrooms across the United States. A recent National Center for Education Statistics (NCES) survey (2010) found that 63% of public school teachers sometimes or often use software for making presentations. As technology continues to evolve with educational practice (Lawrence, 2009), one would hope that teachers are being taught about multimedia learning theory and the effective uses of instructional technology. Tondeur et al. (2011) claimed that “pre-service teacher education should not only focus on how to use technology, but also how technology can be used for teaching and learning” (p. 135). While rigorously peer-reviewed theories of effective multimedia instructional design exist (Mayer, 2005c; 2009), the NCES (2010) study found that only 25% of undergraduate, and 33% of graduate teacher education programs provided a moderate or major extent of teacher’s preparation to use technology within their classroom. These data clearly delineate a gap between multimedia learning theory and what is happening in teacher training that we are yet to bridge. As Pope, Hare, and Howard (2002) summarized, “the digital divide exists not only between those who have technology and those who do not. A gap also exists between what we teach preservice teachers about technology and what we expect them to do with technology as classroom teachers” (p. 191).

To help bridge this gap, teacher educators may turn towards the technologies themselves, as the literature suggests that pre-service teachers can benefit from having role models who teach with technology (Tondeur et al., 2011). For example, using technology in the classroom can help build students’ computer-efficacy (Ertmer & Ottenbreit-Leftwich, 2010). Ertmer and Ottenbreit-
Leftwich explained that computer-efficacy may provide more of an impact on whether or not a teacher uses technology in their classroom than merely the requisite skills and knowledge to do so. Further evidence has shown that it is possible to increase students’ computer-efficacy through pre-service teacher programs. For example, Allsopp, McHattan, and Cranston-Gingras (2009) infused technology into their pre-service teacher curriculum. Over the course of two years, the program required the students to use and present (i.e. teach) with multimedia. After the first semester alone, the students’ perceptions of their ability to use technology increased, \( d=1.58 \) (Allsopp, McHattan, & Cranston-Gingras, 2009).

If a teacher educator is planning to use technology to teach their students about how to design effective multimedia instruction, they have many different instructional tools available to them. Pedagogical agents may present a viable option. In the past, researchers have used pedagogical agents to teach pre-service teachers about topics such as teaching principles (Moreno, 2009) and developing an instructional plan (Baylor, 2002). Due to recent meta-analytical findings about pedagogical agents’ ability to facilitate learning (Schroeder et al., in press), it is plausible that agents may be effective at teaching pre-service teachers about multimedia learning theory.

**Summary**

In closing, theories from a broad range of fields can influence pedagogical agent research. The first experiment explores the presence principle, and was guided by cognitive load theory, social agency theory, and social cognitive theory. The second experiment investigates the effects of manipulating the pedagogical agents’ gender, and was guided by social agency theory, social cognitive theory, and evidence surrounding gender stereotypes. Table 1 summarizes how
The theories influenced each experiment. The next section delineates how these studies took place, describing the participants, methods, and analyses.

Table 1. Summary of each theory’s influence on the experiments.

<table>
<thead>
<tr>
<th>Experiment</th>
<th>Theory</th>
<th>Influence</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Presence Principle</td>
<td>The experimental condition includes a pedagogical agent. The control condition does not include a pedagogical agent.</td>
</tr>
<tr>
<td>Experiment 1</td>
<td>Social Agency Theory</td>
<td>Utilized messages and other social cues (i.e., lip synchronization and gestures) to initiate the learner's social conversation schema.</td>
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<tr>
<td></td>
<td>Cognitive Load Theory</td>
<td>The control condition used a low verbal redundancy environment which has been found to be effective in the past. The experimental condition reduced extraneous cognitive load by minimizing the number of gestures while using a contextually-relevant agent.</td>
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<tr>
<td></td>
<td>Social Cognitive Theory</td>
<td>Utilized an agent that was able to relate more knowledge to learners than they already knew, thus fostering proxy agency.</td>
</tr>
<tr>
<td>Experiment 2</td>
<td>Social Agency Theory</td>
<td>Utilized messages and other social cues (i.e., lip synchronization and gestures) to initiate the learners’ social conversation schema.</td>
</tr>
<tr>
<td></td>
<td>Social Cognitive Theory</td>
<td>Utilized an agent that was able to relate more knowledge to learners than they already knew, thus fostering proxy agency.</td>
</tr>
<tr>
<td></td>
<td>Gender Stereotypes</td>
<td>Utilized one condition with a female agent, and one condition with a male agent. Both agents provided identical instruction and movements. Thus, only the agent's appearance varied between the two groups, thereby isolating effects of the learner's gender stereotypes.</td>
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</table>
CHAPTER THREE

METHODS

The purpose of this dissertation is to investigate how a pedagogical agent’s implementation and gender can affect learners’ cognitive and affective outcomes within a LASP learning environment, while also exploring any influence of a learner’s computer-efficacy. This chapter discusses the participants used in the study, the computer-based materials, how the pedagogical agents were designed, the instruments which were utilized, and the ways in which the experiments took place.

Experiment One: An Empirical Test of the Presence Principle within a LASP Learning Environment

Participants and Design

The participants within this study were limited to aspiring teachers taking courses within the College of Education at a large, public institution in the Pacific Northwest. A priori sample size calculations were conducted to estimate the number of participants needed to detect a statistically significant expected outcome as predicted by previous research findings (Charles, Giraudeau, Dechartres, Baron, & Ravaud, 2009; Schulz & Grimes, 2005). A priori 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. The participants were selected from courses within the College of Education Teaching and Learning department and were randomly assigned to either the experimental or control condition. For this
experiment, there were 38 participants in the control (non-agent) condition, and 41 participants in the experimental (agent) condition.

The average age of the participants was 20.85 \( (SD = 1.99) \) years old, and the sample was 77 percent female. The participants self-identified ethnicity data indicates that 76 percent of the sample were Caucasian, 9 percent reported multiple ethnicities, 8 percent were Hispanic, 4 percent were African American, and 1 percent were 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 that 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\% (\( M = 68.66, SD = 13.52 \)). Finally, 84\% 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\% (\( M = .48, SD = .78 \). Points possible =14). Thus, the participants were considered low prior knowledge learners.

**Apparatus and Instruments**

**Computer-based Materials**

Experiment one investigated the presence principle within a LASP learning environment. Thus, the independent variable was the agent’s presence. The experimental and control conditions both utilized a LASP learning environment, where the learner could fast forward, rewind, and pause the instructional video as they desired.
The control group’s learning environment (Figure 1) was created using Microsoft Movie Maker. The background of the learning environment was a plain black screen. Meanwhile, the narration was provided by an American male’s voice in a conversational style which was recorded using Xtranormal’s (2012) text-to-speech feature (Appendix B). Keywords were displayed on-screen in white text as they were mentioned in the narration to create a low verbal redundancy learning environment.

![Figure 1. Screenshot of the control group’s learning environment.](image)

While Baylor and Ryu’s (2003) control condition included verbatim redundant text to the narration (high redundancy), the present study utilized a more research-informed approach. Recent meta-analytical findings have shown that using a low-degree of correspondence between the spoken and written text can lead to increased learning gains \( (g = .99) \) compared to using verbatim text and narration (Adesope & Nesbit, 2012). Additionally, while adding a background image of the virtual classroom used in the experimental condition was considered, Adesope and
Nesbit’s meta-analysis found that not having images present in the learning materials led to an increase in learning ($g=.45$) when both narration and text were present. Although the meta-analysis found that learning materials presented as text were more effective than those which were accompanied by narration (Adesope & Nesbit, 2012), the non-agent condition utilized narration in order to minimize the number of confounding variables between the control and experimental conditions. For example, since the agent condition provided narration rather than text, utilizing primarily narration to provide the learning materials in the control condition helped reduce confounds between the two conditions. In sum, the control condition was similar to the redundant text and narration condition used by Baylor and Ryu, however the amount of redundancy was reduced according to recent research findings.

The learning environment for the experimental condition was created using Xtranormal (2012), as described in the next section. The background scene was a virtual classroom. The narration was the same audio clip which was used in the control condition; however, a male peer pedagogical agent (Figure 2) was present on the screen and provided the instructional monologue. The agent gestured as it spoke, as research 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 is its ability to move and gesture in relation to objects in the learning environment (Lester et al., 1999), which helps establish the agent’s ability to appear human-like. Finally, the agent’s lips moved during the narration to enhance the illusion of a realistic conversation.
Figure 2. Screenshot from the male peer agent condition which appeared in experiment one and experiment two.

A computer program designed specifically for this study presented the learner with either the experimental or control condition. The program filled the excess area around the LASP learning environment with a grey screen. When participants had completed the instructional materials, they advanced to the post-tests by pressing the “Next” button. The instructional materials took approximately 240 seconds to watch, and the program limited the learners to 600 seconds of instructional time. The excess instructional time was provided so that the learners could rewind and watch portions of the instructional video more than once.

Agent Design
**Xtranormal**

Xtranormal (2012) is an Internet-based software program in which users can create their own multimedia presentations incorporating pedagogical agents. Xtranormal is inexpensive for educators (Xtranormal, 2012) and requires no knowledge of computer programming. Some universities have already begun using Xtranormal to a limited extent for online instruction (Miller, 2011; 2012; WSU eLearning Services, n.d.). If recent trends continue, it is plausible that programs such as Xtranormal will soon be incorporated into K-12 instruction as their cost of implementation is minimal.

Xtranormal (2012) makes it very simple for a new user to create pedagogical agent-based learning environments. First, one must make an account on their website. Next, the user selects which type of background scene and which set of characters they would like to use. After that, the user can pick the individual background scene they would like to use from the set of related choices. The user then picks the virtual characters from the set they have pre-selected, as well as the type of voice the agent will communicate with and any sounds they wish to have in the background. Finally, the user enters their text that they want the agent to narrate, and select any gestures they may want the agent to use by using a drag-and-drop method. Once the program is finished, they simply hit publish and the video is ready for use.

**Peer Agents**

For both experiments in this dissertation, a peer pedagogical agent was used. A review of pedagogical agent studies indicated that most researchers have used instructor-type agents rather than peer agents (Clarebout et al., 2002). Yet, other researchers have suggested that “the benefits of peer interaction for learning and motivation in classrooms have been broadly demonstrated
through empirical studies” (Kim & Baylor, 2006, p. 569). In regard to pedagogical agents, peer or role-model agents may be able to foster affective traits in the learner, such as the learner’s attraction to an unpopular knowledge domain (Kim & Wei, 2011). This may be due to learners viewing pedagogical agents as conversational partners (Louwerse, Graesser, McNamara, & Lu, 2008). One potential drawback of this is that learners tended to perceive agents as “more functional and more intelligent than they actually were” (Kim & Baylor, 2006, p. 573). This could be confusing or even aggravating for learners if they expect to receive specific feedback, but instead are not prompted in an individualized manner. It is plausible that this situation could lead learners to stop working with the system, or lead to decreased engagement with the learning process.

Despite the existence of limited numbers of peer agent studies, there are other reasons why peer agents were chosen for use in this research. For example, it has been suggested that peer agents “may serve as a social model for enhanced motivation and learning in computer-based environments” (Kim & Baylor, 2006, p. 580) which facilitate the illusion of a social interaction taking place (Kim & Baylor, 2006). Thus, peer agents are expected to strongly support social agency theory. Another primary consideration was that peer agents are set in a social-cognitive framework of human cognition (Kim & Baylor, 2006). Kim and Baylor summarized that people derive a stronger sense of personal efficacy from observing peers than from observing adults performing the same skilled tasks. In other words, peer agents should facilitate a learner’s self-efficacy and computer-efficacy, which may lead to increased cognitive outcome scores.

ENaLI
In order to design the peer pedagogical agents used in this study, the Enhancing Agent Learner Interactions (ENaLI) framework was used. ENaLI was proposed to guide “the design of agents and their interactional potential” (Veletsianos, Miller, & Doering, 2009, p. 178). Set in a foundation of cooperative learning, conflict theory, and socio-cultural learning theory, ENaLI delineates 15 design guidelines which may facilitate learner-agent interactions (Veletsianos et al., 2009). The ENaLI framework was chosen to guide the design of the agents used within this study because it focuses on three primary aspects of agent implementation: user interaction, message, and agent characteristics (Veletsianos et al., 2009). Table 2 shows a summary of how 10 of the 15 ENaLI guidelines were used to design the pedagogical agents used in this study. The remaining guidelines were not incorporated due to limitations of the Xtranormal (2012) software.

Veletsianos, Miller, and Doering (2009) suggested that the agent should be sensitive to the learner by addressing requests for information, providing feedback in both summative and formative ways, maintaining appropriate levels of on- and off-topic conversation, and by being redundant. As previously mentioned, when designing the peer agents used for this study, the software’s capabilities presented complications that affected the incorporation of some of the ENaLI guidelines. For example, the agent was not artificially intelligent, so it was not possible to provide the learner feedback or to address requests for information. As mentioned, this may have led to a decreased engagement with the learning material. Due to the aforementioned software limitations, the only user interaction guideline utilized was to ensure that the agent was able to maintain appropriate levels of on- and off-topic conversation. For instance, in the beginning of the interaction with the learner, the agent stated:

“Hey, so I heard from a friend that you were interested in how to teach more effectively with technology. I don’t blame you, technology can be fun to use and if it’s used
effectively, it can be a great teaching tool. There are quite a few things you should keep in mind to keep your teaching with technology simple and effective.”

This passage clearly shows the levels of on topic and off-topic conversation. While the agent clearly communicated that it was there to teach the learner about effectively teaching with technology, there were also off-topic details, such as “I heard from a friend” and “I don’t blame you, technology can be fun to use.”

Table 2. ENaLI framework guidelines that were met in the design of the peer pedagogical agents (Adapted from Veletsianos, Miller, and Doering, 2009, p. 180).

<table>
<thead>
<tr>
<th>Emphasis</th>
<th>Guidelines Utilized</th>
</tr>
</thead>
<tbody>
<tr>
<td>User Interaction</td>
<td>Create appropriate balance between on- and off-topic communication.</td>
</tr>
<tr>
<td>Message</td>
<td>Create relevant messages to the learner’s experience.</td>
</tr>
<tr>
<td></td>
<td>Utilize complete explanations.</td>
</tr>
<tr>
<td></td>
<td>Demonstrate ownership of the communication through verbiage.</td>
</tr>
<tr>
<td></td>
<td>Utilize both verbal and non-verbal communication.</td>
</tr>
<tr>
<td></td>
<td>Describe feelings specifically by name.</td>
</tr>
<tr>
<td>Agent Characteristics</td>
<td>Establish role as peer.</td>
</tr>
<tr>
<td></td>
<td>Establish credibility.</td>
</tr>
<tr>
<td></td>
<td>Utilize polite conversation.</td>
</tr>
<tr>
<td></td>
<td>Emphasize a relevant visual representation.</td>
</tr>
</tbody>
</table>
While the agent’s interaction with the learner is important, it is well known that communication takes place on many different levels, both verbally and non-verbally. Veletsianos et al. (2009) delineated six different guidelines for pedagogical agent communication with the learner. These guidelines are summarized in Table 2. The software used to create the agents for these experiments allowed for the incorporation of all six guidelines in an effort to increase the effectiveness of the pedagogical agent’s communication of the learning material.

Finally, the ENaLI framework provides direction for the agent’s physical appearance and communication style. The agent’s appearance is important, as studies have shown that learners’ stereotype on-screen characters (Moreno et al., 2002). Veletsianos et al. (2009) supported these findings and suggested that “the visual representation of a means for communication [i.e., the agent] can be interpreted in many ways by learners before any meaningful interaction takes place” (p. 186). As such, four out of the five agent characteristic design considerations outlined by the ENaLI framework were utilized in the design of the peer agents (Table 2). One drawback of the Xtranormal (2012) program is that the text-to-speech synthesizer provided by Xtranormal (2012) did not allow for manipulation and control over the agent’s voice expressions and inflection. Thus, the final design consideration in this category, which is to use an expressive voice, was not utilized (Veletsianos et al., 2009).

**Demographic Questionnaire**

The demographic questionnaire was used to describe the participant population. It consisted of eight questions which addressed the student’s age, gender, ethnicity, and previous experiences with multimedia and multimedia learning theory (Appendix B).
Computer-efficacy Scale

The computer efficacy scale (Appendix D) was used to measure the individual’s computer-efficacy. The scale used for this study was an adapted version of Compeau and Higgins (1995) computer self-efficacy scale. The scale consists 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 $\alpha = .80$ (Compeau & Higgins, 1995). In experiment one, the scale’s internal consistency reliability was found to be $\alpha = .92$.

Pre-test

The pre-test consisted of three free response questions concerning cognitive load theory, the modality principle, and the split-attention principle (Appendix E). The students earned one point for each correct answer they wrote down, with a maximum of 14 points possible. 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 learners earned one point for correctly describing the split-attention principle, and for the third question the learners earned one point for correctly describing the modality principle. These questions were designed to investigate if the learners had any prior knowledge about the learning materials while minimizing any error due to guessing.

Post-test

The post-test consisted of three different types of questions which addressed cognitive outcomes (Appendix F). First, learners were given one free recall question where they were
asked to write down everything they could remember from the instructional video. The question had a maximum of 18 points available, with points given for correctly identifying (1 point) and describing (1 point) 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.

Next, learners were asked thirty multiple choice questions about cognitive load theory, the modality principle, and the split-attention principle. Each correct answer was worth one point. These questions asked learners to both recall specific information as well as apply their knowledge to a hypothetical situation. The scale’s internal consistency reliability was found to be $\alpha = .71$.

Finally, the learners were given one free response transfer question in which they were asked to design a lesson plan utilizing cognitive load theory, the split-attention principle, and the modality principle. The free response transfer question had a maximum score of 18, with points given for each correct reference to theory when describing their lesson plan (see grading for free recall question).

In order to measure the affective outcomes, the learners completed the Agent Persona Instrument (Ryu & Baylor, 2005) which measured the 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 ($\alpha = .87$), and five items which addressed how engaging the agent was ($\alpha = .86$) (Ryu & Baylor, 2005). To respond, learners utilized a five point Likert scale, where 1 is “Strongly disagree” and 5 is “Strongly Agree”. For this experiment, the
scale’s internal consistency reliability was found to be $\alpha = .94$ for facilitated learning, $\alpha = .87$ for credibility, $\alpha = .92$ for human-like, and $\alpha = .91$ for engaging.

Procedure

First, potential participants were identified through their current coursework. Certain classes were selected because they were geared toward preparing aspiring teachers to obtain their teaching certification. Once classes were identified, class rosters were obtained from the instructors and a class period was designated for the students to participate in the experiment if they chose to. The class roster was used to randomly assign participants to each group via the use of a random number generator.

On the day of the administration of the experiment, the researcher met with the classes in their classroom. The researcher then brought the class into a different classroom which contained 30 identical Dell computers with 15 inch screens. Each computer had its own set of headphones. The screen resolution was set to 1280x1024, the university’s default setting. Upon entering the classroom, the participants were given 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 using their own computer station. The experiment took 20-35 minutes to complete.
Experiment Two: Exploring the impact of agent gender within a LASP learning environment.

Participants and Design

The participants within this study were limited to aspiring teachers taking courses within the College of Education of a large, public institution in the Pacific Northwest. As with experiment one, a-priori sample size calculations were conducted (Charles, Giraudeau, Dechartres, Baron, & Ravaud, 2009; Schulz & Grimes, 2005). Apriori sample size calculations indicated that in order to obtain $\alpha = .05$ with a statistical power of .80 and a desired effect size of $d = .63$ (average effect size extracted for human-like, facilitating their learning, and engaging from Kim, Baylor, & Shen, 2007), 32 participants were needed per group. Thus, 77 aspiring teachers participated in this study for course credit. There were 40 participants in the male agent condition and 37 participants in female agent condition. The participants were randomly assigned to one of the two conditions.

The average age of the participants in this experiment was 20.75 ($SD = 1.60$) years old, and 74% of the participants were female. The average participant had completed 2.5 years of post-secondary education. The participants’ self-identified ethnicity data indicated that 86% of the sample were Caucasian, 8% reported multiple ethnicities, and 4% were Hispanic. Two percent of the participants chose not to report their ethnicity. Ninety five percent of the participants reported that their first language was English, while 3% indicated that their first language was Spanish. Two percent of the participants chose not to report their first language. The participants were, as a group, moderately confident in their ability to use computers. The participants average self-rated computer-efficacy was 69% ($M = 68.64, SD = 13.2$). Finally,
71% of the participants indicated that they had not received formal instruction about multimedia learning theory, however they sometimes use multimedia when they teach ($M = 3.35, SD = .96$, where 1 is “never” and 5 is “almost always”). The participants were considered low prior knowledge learners, as their average pre-test score was 4% ($M = .55, SD = .82$, points possible =14).

*Apparatus and Instruments*

*Computer-based Materials*

This experiment utilized the same virtual classroom as the basis of the learning environment as in the experimental condition of experiment one. The male agent condition utilized the same male agent and instructional monologue as the experimental condition in experiment one (Figure 2). The female agent condition utilized the same environment as the male agent condition. However, the male peer agent was replaced with a female peer agent (Figure 3). Likewise, the narration was replaced by a female American’s voice using the Xtranormal (2012) text-to-speech feature. The narration was identical in content to the male agent condition, as were the gestures and lip movements the agent provided. Both conditions utilized the same program as used in experiment one, which limited instructional time to 600 seconds.
Figure 3. Screenshot of the female pedagogical agent condition.

Demographic Questionnaire

The demographic questionnaire (Appendix B) was identical to the one used in experiment one.

Computer-efficacy Scale

The computer-efficacy scale (Appendix C) was identical to the scale used in experiment one. For this experiment, the internal consistency reliability was found to be $\alpha = .91$.

Pre-test

The pre-test was identical to the pre-test used for experiment one.
Post-test

The post-test consists of three different types of questions (Appendix E) which were identical to those used in experiment one. For this experiment, the internal consistency reliability of the multiple choice questions was found to be $\alpha = .70$. The internal consistency reliability of the affective scale measures were found to be $\alpha = .94$ for facilitates learning, $\alpha = .87$ for credibility, $\alpha = .88$ for human-like, and $\alpha = .89$ for engaging.

Procedure

The procedure for experiment two was identical to the procedure of experiment one.
CHAPTER FOUR

RESULTS

Researchers have suggested that “the relationship between student achievement and use of technology has already begun to prove positive in nature” (Koch, 2009, p. 159-160). The purpose of this dissertation was to explore the use of one technology tool, a pedagogical agent, in a LASP learning environment. This chapter provides a discussion of the results. First, experiment one is discussed, followed by experiment two. The results for each experiment are organized by research question.

Experiment One

The purpose of the first experiment was to explore the impacts of either a pedagogical agent or a low verbal redundancy control condition on learner’s cognitive and affective outcome scores. The experiment also investigated any influence of a learner’s computer-efficacy. In the next section, the results of experiment one are presented in relation to each research question.

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

Before analyzing the data using multivariate analysis of variance (MANOVA), the data were examined to ensure that they were normally distributed. Tabachnick and Fidell (2013) suggested that examination of a graphical representation of the data can be used to determine normality. After examination of the graphs of the learner’s free recall scores, multiple choice
scores, and transfer test scores, it was apparent the data were normally distributed. Table 3 shows
the means and standard deviations of the data.

Table 3. Results of cognitive measures for experiment one.

<table>
<thead>
<tr>
<th></th>
<th>Control (n = 38)</th>
<th>Agent (n = 41)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>SD</td>
</tr>
<tr>
<td>Pre-test</td>
<td>0.37</td>
<td>0.71</td>
</tr>
<tr>
<td>Free Recall</td>
<td>6.95</td>
<td>3.52</td>
</tr>
<tr>
<td>Multiple Choice</td>
<td>16.92</td>
<td>4.32</td>
</tr>
<tr>
<td>Transfer</td>
<td>3.39</td>
<td>2.55</td>
</tr>
</tbody>
</table>

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

Next, an independent samples t-test was used to investigate if there were significant
differences between groups on their pre-test scores. Result of the t-test revealed that there were
no significant differences in pre-test scores, $t = -1.236 \ (p > .05)$. Hence, 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. The
result of Box’s $M = 3.135 \ (p > .05)$, satisfied the assumption of homogeneity within the
covariance matrices of the sample. Levene’s tests were used to evaluate the error variance with
the sample for each cognitive dependent variable. Levene’s tests revealed $p$ values greater than
.05, indicating that there was homogeneity within the error variances within the sample.

The results from the MANOVA revealed that there were not statistically significant
differences between groups on any of the cognitive outcome measures ($\text{Wilks'} \ \lambda = .916, F(3, 75) = 2.281, p > .05$). The analysis revealed a partial $\eta^2 = .08$, with an observed power of .55. Despite
the use of three measures of learning, these results are consistent with those of Baylor and Ryu’s
(2003) study, as well as other pedagogical agent literature (for a review, see Heidig & Clarebout, 2011). These findings were unexpected, as some have argued that contextually-relevant pedagogical agents may be more effective for learning than non-relevant agents (Veletsianos, 2007). Yet, these data show that in a LASP learning environment a contextually-relevant, peer pedagogical agent’s presence does not equate to increased learning outcome scores.

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?

Before utilizing MANOVA to examine if differences existed between groups, the data were examined for normality. First, a graphical representation of the data for the facilitated learning, credible, human-like, and engaging scales were examined and compared to a normal distribution (Tabachnick & Fidell, 2013). The examination indicated that the data for each scale were normally distributed. The means and standard deviations of the data is presented by group and organized by scale in Table 4.

Table 4. Results of affective measures for experiment one.

<table>
<thead>
<tr>
<th>Scale</th>
<th>Control Mean (n = 38)</th>
<th>Control SD</th>
<th>Agent Mean (n = 41)</th>
<th>Agent SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Facilitated</td>
<td>26.34</td>
<td>9.06</td>
<td>27.02</td>
<td>8.73</td>
</tr>
<tr>
<td>Learning</td>
<td>26.34</td>
<td>9.06</td>
<td>27.02</td>
<td>8.73</td>
</tr>
<tr>
<td>Credible</td>
<td>15.71</td>
<td>4.72</td>
<td>17.05</td>
<td>3.91</td>
</tr>
<tr>
<td>Human-Like</td>
<td>9.26</td>
<td>4.45</td>
<td>11.32</td>
<td>4.17</td>
</tr>
<tr>
<td>Engaging</td>
<td>10.26</td>
<td>4.29</td>
<td>11.80</td>
<td>4.32</td>
</tr>
</tbody>
</table>

MANOVA was conducted with the control and agent conditions as the fixed factor (i.e. independent variable) and the Agent Persona Instrument scales (Ryu & Baylor, 2005) as the dependent variables. Box’s $M = 10.561, p > .05$, satisfied the assumption of homogeneity within the covariance matrices. Levene’s tests were used to evaluate the equality of error variances for each affective variable. Levene’s tests indicated that there was homogeneity within the error variances, with all $p$ values being greater than .05.

The MANOVA revealed no significant differences between groups in any of the affective measures (Wilks’ $\lambda = .907$, $F(4, 74) = 1.907, p > .05$, partial $\eta^2 = .09$, observed power = .55). In other words, the pedagogical agent was not found to be more credible, human-like, engaging, or able to facilitate learning any more effectively than the low verbal redundancy condition.

These results greatly differ from 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 no agent condition. There are many reasons why these differences may have occurred. First, this study used an instrument which has validity evidence to support its use, while the measures used in Baylor and Ryu’s study did not. Perhaps the instruments used in this study were able to capture a more valid evaluation of the pedagogical agent and the learning environment. Another plausible rationale could be the reliability of the measures used in each study. The scales used in this study had internal consistency reliability exceeding $\alpha=.87$ for all measures, while the scales used in Baylor and Ryu’s study ranged from $\alpha=.68$ to $\alpha=.74$. The psychometric differences in the scales used between the studies may explain why Baylor and Ryu found statistically significant results, while this experiment did not.
Another plausible rationale is that the agent in this study appeared as a peer, while the agent in Baylor and Ryu’s (2003) study appeared as a wizard. Very little literature exists around the use of peer agents. Perhaps peer agents do not have the ability to foster these affective traits in learners to the same extent as a non-human character? Further research may explore this possibility.

Finally, the pacing of the learning environment may have influenced these findings. While the Baylor and Ryu’s (2003) study appears to be learner-paced, this experiment utilized a LASP environment. In a learner-paced environment, the learner must click on a button to bring them to the next screen, or to hear the agent give the next piece of advice. In the LASP environment, the pedagogical agent provides an instructional monologue at a set speed, which the learner can then rewind, pause, or fast-forward. The fundamental differences between the two environments may have led to the differences found in affective measures. 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 these differences.

Research Question Three: How does a learner’s computer-efficacy influence the relationship between cognitive and affective outcomes and whether they learned when learning with a pedagogical agent compared or to a low verbal redundancy condition?

In order to investigate this question, there must be significant differences between the groups’ mean scores in their self-rated computer-efficacy. If significant differences exist, then multivariate analysis of covariance (MANCOVA) would be used to evaluate how computer-efficacy moderates the affective and cognitive outcomes.
An independent samples t-test was used to compare the mean scores of the two groups on the self-rated computer-efficacy measure. The t-test revealed that there was no statistically significant difference between groups ($t = -.68, df = 77, p > .05$). Hence, MANCOVA was unnecessary as computer-efficacy did not influence the relationship between the group the individual was assigned to and their cognitive or affective outcomes within this sample. Future research should use a more heterogeneous sample of participants in order to more fully investigate the moderating effects of a learner’s computer-efficacy on learning and perception when working with pedagogical agents.

Experiment Two

The purpose of the second experiment was to examine how manipulating the gender of the pedagogical agent could affect cognitive and affective outcome scores. The learners’ computer-efficacy was also measured to see if it could influence the cognitive and affective outcome scores depending upon the pedagogical agent appeared as a female or a male. The next section delineates the findings of experiment two by research question in relation to previous research.

*Research Question One: How does learning with a male pedagogical agent affect the learner’s free recall, multiple choice, and transfer scores compared to learning with a female agent?*

In order to investigate any differences between groups among the cognitive measures, MANOVA can be used. First, the data were examined graphically for each variable to check for normality (Tabachnick & Fidell, 2013). Examining the data in comparison with the normal distribution confirmed that the data were normally distributed. The data for each cognitive measure are presented in Table 5.
Next, an independent samples t-test was used to investigate if there were significant differences between groups on their pre-test scores. The t-test revealed that $t = .884$ ($p > .05$).

Since there were no significant differences in pre-test scores, MANOVA was conducted with the agent’s gender as the fixed factor (i.e. independent variable) and the free recall, multiple choice, and transfer tests as the dependent variables. Box’s $M = 3.67$, $p > .05$, satisfied the assumption of homogeneity among the sample’s covariance matrices. Next the equality of the error variance was evaluated for each cognitive measure (free recall, multiple choice, and transfer tests) using Levene’s test. Levene’s tests indicated $p$ values greater than .05 for all measures, which indicates homogeneity among the sample’s error variances.

Table 5. Results of cognitive measures for experiment two.

<table>
<thead>
<tr>
<th></th>
<th>Male ($n = 40$)</th>
<th>Female ($n = 37$)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>SD</td>
</tr>
<tr>
<td>Pre-test</td>
<td>0.63</td>
<td>0.93</td>
</tr>
<tr>
<td>Free Recall</td>
<td>6.68</td>
<td>4.02</td>
</tr>
<tr>
<td>Multiple Choice</td>
<td>17.08</td>
<td>4.42</td>
</tr>
<tr>
<td>Transfer</td>
<td>3.20</td>
<td>2.99</td>
</tr>
</tbody>
</table>

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

The MANOVA revealed Wilks’ $\lambda = .94$, $F(3, 73) = 1.60$, $p > .05$, with a partial $\eta^2 = .06$ and an observed power of .40. Thus, there were no statistically significant differences in cognitive outcomes dependent upon the gender of the pedagogical agent.

Overall, these findings are consistent with some literature around pedagogical agent gender. While Moreno et al. (2002) and one experiment by Kim, Baylor, and Shen (2007) showed that male pedagogical agents were more effective for learning than female pedagogical
agents, Baylor and Kim (2004) found that the agent’s gender did not produce differences in learning outcomes. The outcome of this experiment is also consistent with one experiment within Kim, Baylor, and Shen’s work, which found that there were no differences in learning outcomes between agent genders. Examined holistically, these findings indicate that if learners do stereotype pedagogical agents by their physical appearance, these stereotypes do not significantly affect their learning outcome scores in a LASP learning environment. These results further support the findings of Harrison and Atkinson’s (2009) work, which found that the gender of the voice providing narration did not significantly affect learning outcomes.

Research Question Two: How does learning with a male pedagogical agent affect the learner’s perception of the agent compared to a female agent?

MANOVA can be used to investigate if differences existed in how the pedagogical agents were perceived by learners depending upon if they worked with a female or male pedagogical agent. First, the data for each scale (facilitated learning, credible, human-like, and engaging) were individually examined for normality by examining the data graphically and comparing it to a normal distribution (Tabachnick & Fidell, 2013). Examination of the data indicated that the data were normally distributed for each scale. The means and standard deviations for each scale are presented in Table 6.

MANOVA was conducted using the agent’s gender as the independent variable and the Agent Persona Instrument scales (Ryu & Baylor, 2005) as the dependent variables. Box’s $M = 15.58, p > .05$, which satisfied the assumption of homogeneity within the covariance matrices. Levene’s test of equality of error variances was then used to see if heterogeneity existed within
the error variance of each scale. Levene’s tests all indicated a $p$ value of greater than .05, which indicates homogeneity of error variance.

Table 6. Results of affective measures for experiment two.

<table>
<thead>
<tr>
<th></th>
<th>Male</th>
<th>SD</th>
<th>Female</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td></td>
<td>Mean</td>
<td></td>
</tr>
<tr>
<td>Facilitated Learning</td>
<td>26.18</td>
<td>8.38</td>
<td>26.62</td>
<td>9.61</td>
</tr>
<tr>
<td>Credible</td>
<td>16.28</td>
<td>3.97</td>
<td>15.73</td>
<td>4.79</td>
</tr>
<tr>
<td>Human-Like</td>
<td>10.43</td>
<td>4.19</td>
<td>10.57</td>
<td>4.57</td>
</tr>
<tr>
<td>Engaging</td>
<td>11.15</td>
<td>4.46</td>
<td>11.03</td>
<td>4.37</td>
</tr>
</tbody>
</table>


The MANOVA revealed no significant differences between groups in any of the affective measures ($\text{Wilks’ } \lambda = .98$, $F(4, 72) = .34$, $p > .05$, partial $\eta^2 = .02$, observed power = .13). As such, pedagogical agents of different genders were not perceived differently by the participants.

These findings are not as consistent with previous research as one may expect. For example, Moreno et al. (2002) found that the gender of a pedagogical agent caused the learner to invoke stereotypes. As such, examining literature surrounding gender stereotypes would show that male agents would likely be rated as higher on the credibility scale since they are stereotyped as being more authoritative (Madrid & Hughes, 2010). Similarly, one may expect that female agents would be rated higher on the facilitated learning scale since they are stereotyped as being more supportive (Madrid & Hughes, 2010). Yet, the findings of this experiment do not support these conclusions. Perhaps since the agents appeared as peers, rather than older instructors, the same stereotypes were not invoked within the learners?
The findings of this experiment somewhat differ from the findings of Kim, Baylor, and Shen’s (2007) work. Kim, Baylor, and Shen found that male agents were perceived more positively than female agents, and that male agents were rated as more interesting than female agents. However, this may be due to a difference in the scales used and what they were meant to measure. While Kim, Baylor, and Shen specifically evaluated interest, this experiment investigated other variables such as the pedagogical agent’s ability to facilitate learning, its credibility, how human-like it was, and how engaging it was. However, if male pedagogical agents were perceived more positively than female agents, one would have expected the male agent group to have rated one or more scales used in this experiment significantly higher than the female agent group. Rather, the findings show that in a LASP learning environment, the gender of the peer pedagogical agent did not affect how it was perceived.

The nature of the LASP learning environment may also have impacted these findings. Since the LASP learning environment presents an instructional monologue while a learner-paced environment requires the learner to interact with the computer to move forward with the lesson, the learner may not have felt as engaged with the LASP system. This lack of engagement is reiterated in the mean scores for each group, which indicated an average engagement rating of less than 50% of the total possible score. Being that the learners indicated they were not fully engaged by the presentation, could this have led the participants to not invoke gender stereotypes to the same level as they would have if they had been more engaged with the pedagogical agent and the learning environment? Future research can explore the link between engagement and gender stereotypes.
Research Question Three: How does the learner’s computer-efficacy influence the relationship between cognitive and affective outcomes when learning from pedagogical agents of different genders?

Before investigating how a learner’s computer-efficacy moderates their cognitive and affective outcomes scores through MANCOVA, significant differences must be found between the groups. In order to test this, an independent t-test was used to compare the two group mean scores for computer-efficacy. The t-test revealed that there was no significant difference between groups ($t = .44$, $df = 75$, $p > .05$). Thus, using a MANCOVA was not necessary as the learner’s computer-efficacy did not influence their learning or perceptive measure scores at a statistically detectable level.
CHAPTER FIVE
DISCUSSION

The findings of this dissertation have implications for both theory and practice. In this chapter, the theoretical and practical implications of each experiment are presented, as well as each experiment’s inherent limitations, and suggestions for future research.

Experiment One

The purpose of the first experiment was to explore the presence principle in a LASP learning environment. Findings revealed that there were no significant differences in learning or perceptive outcomes between the group which learned with a pedagogical agent and the group which learned with a low verbal redundancy text and audio control condition. In the next section, the theoretical implications of these findings are presented, organized by the theoretical foundation of the experiment’s design.

Theoretical Implications

The first experiment acted as a test of the presence principle in a LASP learning environment. The presence principle states that the pedagogical agent’s voice is more important than its physical appearance, and that its appearance on screen is not necessary for increased learning outcomes (Mayer, Dow, & Mayer, 2003). Mayer, Dow, and Mayer further suggested that the agent was merely a seductive detail, which may actually decrease learning if it is distracting. The findings of experiment one support the presence principle in that no significant differences were found in the cognitive outcome scores between the pedagogical agent group and the control group. Yet, the pedagogical agent was not found to be distracting and thus deleterious for learning outcome scores. Rather, the pedagogical agent appeared to be equally as effective
for learning as a low verbal redundancy condition within a LASP learning environment. Thus, experiment one’s findings were consistent with the presence principal in that the agent’s voice, rather than its physical appearance, seems to be most important for fostering learning outcomes in a LASP environment. Had the agent’s image been more important than its voice, the pedagogical agent group would have scored significantly higher than the control group on cognitive measures.

The presence of a pedagogical agent also did not lead to an increase in the learners’ perceptive ratings of the system. Rather, no significant differences were found between the pedagogical agent and low verbal redundancy conditions. In the past, researchers have found that even if no differences in learning outcomes exist, the learners found the pedagogical agent condition easier to use and more enjoyable than the non-agent condition (Moundridou & Virvou, 2002). Thus, for tasks in which an instructor specifically hopes to improve the learner’s perceptive outcomes rather than their cognitive outcomes, a pedagogical agent may be an effective option (Kim & Wei, 2011). However, the pedagogical agent used in Moundridou and Virvou’s study was powered by artificial intelligence which could identify where students made mistakes solving problems. The agent could then address these issues directly. The pedagogical agents used in this dissertation were not intelligent, and could only provide the instructional monologue with no additional customized instruction. Could the individualized instruction provided by an artificially intelligent agent be the key to obtaining higher affective scores from learners? Future research should investigate if the agent’s ability to interact with the student can lead to an increased perception of the system, or if it is merely the agent’s image alone which fosters these affective benefits.
The findings of experiment one also extends the literature around social agency theory. Both the pedagogical agent and non-agent conditions utilized the same instructional monologue containing identical social cues. The narration was provided by a voice generated by the Xtranormal (2012) text-to-speech generator. As such, there is not much to add to the literature in regards to the impact of the agent’s voice since it was not varied between the two conditions. However, the pedagogical agent condition utilized gestures while the control condition did not have an agent present. Thus, there were no gestures in the non-agent condition. While gestures have been found to be helpful for understanding human communication (Hostetter, 2011) and in other pedagogical agent studies (Moreno, Reislein, & Ozogul, 2010), they did not foster increased learning or perceptive outcome scores in this experiment. It is plausible that gestures were not advantageous because there was not anything for the agent to reference on the screen. For example, there were no diagrams or charts for the pedagogical agent to draw the learners’ attention to as there have been in other studies (e.g. Moreno, Reislein, & Ozogul, 2010). While in the design of this experiment, the gestures were added to foster the agent’s deictic believability (Lester, Voerman, Towns, & Callaway, 1999), the gestures were not designed to be salient in the learning process. As such, the results show that the gestures appear to have not made any significant difference in regards to learning or perceptive outcome scores in this experiment. Future research should investigate whether having charts or pictures referenced through agent gestures in a LASP learning environment produces significant cognitive or affective benefits as it has in other studies.

The results of this experiment also make a significant contribution to cognitive load theory. Some scholars have posited that pedagogical agents may increase the extraneous cognitive load of the learning environment (Clark & Choi, 2007). Others have suggested that due
to a split-attention effect and the limited nature of the working memory, a highly animated and
visible pedagogical agent may not lead to meaningful learning (Moreno, 2005). However, the
results of experiment one show that the low verbal redundancy condition was equally as effective
as the pedagogical agent condition in the LASP learning environment. These findings tell us a
few different things. First, the pedagogical agent did not appear to cause extraneous cognitive
load for the learner. The low verbal redundancy environment contains few features which could
create cognitive load since only keywords were shown on the screen while the user listened to
the instructional monologue. Alternatively, the pedagogical agent condition included the agent
itself, the instructional monologue, a virtual classroom, and gestures. Thus, it is apparent that the
pedagogical agent condition potentially has the ability to increase the extraneous cognitive load
of the environment. However, if this increase in extraneous cognitive load had occurred, then the
low verbal redundancy condition would have outperformed the pedagogical agent condition in
the cognitive outcome scores. Yet, this was not the case. As such, it is plausible that
contextually-relevant peer pedagogical agents do not cause extraneous cognitive load in LASP
learning environments. However, one question still remains: do contextually-relevant
pedagogical agents not cause extraneous cognitive load in a LASP learning environment because
the cognitive load the agent may cause decreases over time (as suggested by Sweller, 2005), or
are pedagogical agents simply not seen as a non-meaningful part of the LASP learning
environment, and are therefore ignored (Moreno, 2005)? Future research can investigate this
question.

Consistent with other studies (e.g. van Mulken, André, & Muller, 1998), the pedagogical
agent used in experiment one did not cause a split-attention effect. In other words, the
pedagogical agent did not lead to a deleterious learning outcomes compared to the non-agent
condition. Van Mulken, André, & Muller speculated that this may, instead, be due to the antagonistic relationship between motivation and distraction. While the participants may have found the agent motivating, they had to cope with the agent’s physical image creating a distraction. Thus, while the learners may have reaped the benefits of the additional motivation, the deleterious effects of distraction lead to no advantage in learning outcome tests. A review of the literature also found results consistent with these findings, suggesting that the split-attention effect may not be present when learning with pedagogical agents (Moreno, 2005).

The results from experiment one also inform social cognitive theory. As mentioned earlier, the pedagogical agent in this experiment was meant to foster proxy agency by having more relevant knowledge than the learner. Since no significant differences were found between groups in cognitive outcome scores, it is apparent that the pedagogical agent and the low verbal redundancy environment were both able to foster proxy agency without any meaningful advantage from either condition. Moreover, the findings showed that there were no significant differences found in the learner’s perceptions of the system. These results imply that the pedagogical agent did not foster any additional efficacy in the learner compared to the low verbal redundancy condition. Rather, the two conditions produced very similar results. This being the case, it is plausible that both conditions were seen as proxy agents, and both were able to foster at least some efficacy in the learner. However, due to the homogeneous nature of the sample, it was not possible to investigate if a learner’s computer-efficacy influenced either their affective or cognitive outcome scores. As presented earlier, this may be an important variable. Future research should investigate the influence of a learner’s computer-efficacy on their cognitive and affective outcomes when learning with pedagogical agents in a LASP learning environment.
As shown, the results from experiment one inform the presence principle, cognitive load theory, and social cognitive theory. The next section discusses the practical implications of the research, with a strong emphasis on bridging the theory-practice gap.

Practical Implications

The results from experiment one show that there are no meaningful differences in learning or perceptive outcome scores from learning with a pedagogical agent compared to a low verbal redundancy LASP learning environment. These findings have important implications for both teacher educators and teachers themselves.

As mentioned, the program which aspiring teachers go through to obtain their certification can be highly influential for their development (Tantekin Erdin, 2009). For example, research has shown that pre-service teacher programs can help instill computer-efficacy in aspiring teachers (Allsopp, McHattan, & Cranston-Gingras, 2009). One way this can be done is to expose the aspiring teachers to role models who use technology effectively in their teaching (Tondeur et. al., 2011). If combined with hands-on experience, using technology in the classroom can help build the student’s computer-efficacy (Ertmer & Ottenbreit-Leftwich, 2010). The results of experiment one show that both the pedagogical agent condition and the low verbal redundancy condition in a LASP learning environment were equally effective at fostering cognitive and affective outcomes among pre-service teachers. For a teacher-educator, this means that it does not make a difference which condition you choose to teach your class with. In other words, aspiring teachers will learn from and perceive the LASP learning environment in similar ways regardless of if a pedagogical agent is present or not. These findings add yet another tool to the teacher-educator’s tool belt. For example, a teacher-educator could use a pedagogical agent...
in a LASP learning environment in order to introduce a lesson, or present a discussion topic. The next day, the low verbal redundancy condition could be used to perform the similar tasks. Varying the types of instruction not only keep the learning situations novel for students, but also expose the students to different kinds of technology they can teach with. Using technology in this way, and allowing the students’ time to develop their own presentations using the different technologies may increase their computer-efficacy (see Allsopp et al., 2009).

Another implication of Experiment One’s results is that if a pedagogical agent would cost more to integrate into a LASP learning environment than a low verbal redundancy condition, there will be no detriment to students’ learning or perceptive outcomes if one chooses not to invest in the pedagogical agent software. While some programs have been developed which allow the integration of pedagogical agents into LASP learning environments for little or no cost to educators (e.g. Xtranormal, 2012), many programs still require fiscal or knowledge resources in order to integrate an agent. Experiment One has shown that a teacher need not incur these costs in order to most effectively teach their students if they desire to utilize a LASP learning environment.

While experiment one has provided many implications for both theory and practice, it is not without its inherent limitations. In the next section, these limitations are delineated and suggestions are presented for how future researchers can avoid them.

Limitations

One of the most notable limitations of Experiment One was the voice which was used to provide the narration. For this experiment, the voice was generated using Xtranormal’s (2012) text-to-speech feature. However, using this feature presented certain limitations. For example,
the voice was clearly computer-generated and sounded choppy at times. Moreover, there was no way to control the speed of the agent’s voice, nor its inflection. Numerous participants made statements about the quality of the agent’s voice even though they were not prompted to do so. For example, one participant stated that, “It was hard to understand the voice and [the] breaking apart of the words [was] causing me to lose interest in the video.” Clearly, the voice used may have impacted the findings of this research. Despite meta-analytical findings which suggested that a pedagogical agent’s voice does not lead to large differences in learning outcome scores (Schroeder et al., in press), multimedia research findings have shown that a recorded human voice is more effective for learning than a computer-generated voice (Atkinson, Mayer, & Merrill, 2005; Harrison & Atkinson, 2009; Mayer, 2005; Mayer, Sabko, & Mauntone, 2003). Future research should explore how a recorded human voice may influence learning and perceptive outcomes compared to a text-to-speech generated voice to see if the multimedia findings of other studies can be extended to a LASP learning environment.

Another limitation of Experiment One is the issue of confounding variables. As is common throughout other pedagogical agent studies and has been identified by other researchers (e.g. Clark & Choi, 2005), the control and experimental groups in this study differed by more than only the variable in question (i.e., the agent’s presence). Thus, it is not possible to deduce if it was the pedagogical agent’s presence, its gestures, its appearance as a peer, or its contextual relevance which produced the same effects on learning and perceptions as the low verbal redundancy environment. Now that findings have shown that low verbal redundancy conditions are equally as effective as pedagogical agents in a LASP learning environment, researchers can isolate and explore the impacts of these features.
The final limitation of experiment one was the homogeneous nature of the participants. While the homogeneity of the group was intentional, as aspiring teachers were chosen as the sample, it also had an unexpected backlash effect in that there were no significant differences among their computer-efficacy scores. Thus, this potentially important variable could not be evaluated for its moderating effects on either cognitive or affective measures. Future research around computer-efficacy should emphasize a more heterogeneous group of participants to ensure that significant differences are found and the influence of computer-efficacy can be evaluated.

Summary

Despite experiment one’s limitations, the findings show that a contextually-relevant, peer pedagogical agent is equally as effective in a LASP learning environment as a low redundancy condition. Despite the non-significant findings between groups, these results remain very powerful and informative. Adesope and Nesbit’s (2012) meta-analytical findings have shown that low verbal redundancy conditions can provide large learning benefits compared to voice-only presentations ($g=.99$, $p<.05$). Previously, a non-relevant pedagogical agent was compared to fully redundant conditions and found to be equally as effective for learning outcome scores (Baylor & Ryu, 2003). Compared to narration alone, fully redundant learning environments only produce small effects on learning ($g=.21$, $p<.05$, Adesope & Nesbit, 2012). Thus, Experiment One has shown that in a LASP learning environment, contextually-relevant peer pedagogical agents can be more effective for learning than previous research with non-relevant agents has indicated. Future research should compare a contextually-relevant peer pedagogical agent in a LASP learning environment to a narration only condition to quantify this advantage.
Experiment Two

The purpose of the second experiment was to examine the differences in learning and perceptive outcomes when learners worked with either a female or male pedagogical agent. The experiment also investigated the influence of a learner’s computer-efficacy on their cognitive and affective outcomes. The results of the second experiment have implications for both theory and practice. The next section delineates the theoretical implications of the results, organized by the theoretical foundations of the experiment.

Theoretical Implications

The findings from Experiment Two can be used to extend social agency theory. Social agency theory predicts that social cues in multimedia messages can increase a learner’s cognitive outcome scores (Louwerse, Graesser, Lu, & Mitchell, 2005; Mayer, Sabko, & Mautone, 2003; Moreno et al., 2001). The purpose of Experiment Two was to further explore this hypothesis by investigating if manipulating the pedagogical agent’s gender would influence the way social cues were perceived by learners. The findings indicated that both male and female pedagogical agents are able to provide the same level of instruction. In other words, a learner working with a female pedagogical agent did not produce significant differences in either cognitive or affective outcomes compared to those who worked with male pedagogical agents. Thus, it is clear that in a LASP learning environment, either gender of pedagogical agent can provide adequate social cues through their communication with the learner.

As mentioned, Experiment Two was also used to investigate how perceptions can be affected by the learners projecting gender stereotypes onto the pedagogical agents by presenting identical communication from both the male and female pedagogical agent conditions. In this
way, the teacher’s stereotypes could be eliminated by providing identical instruction to both male and female participants. The findings showed that there were not significant differences found in how the agents were perceived by the learners depending upon if they worked with either a male or female pedagogical agent. Despite literature surrounding pedagogical agent gender which suggests that male agents may be perceived more positively than female agents (Kim, Baylor, & Shen, 2007), this was not the case when the pedagogical agents appeared in a LASP learning environment.

Yet, Experiment Two does leave one unresolved question: perhaps the decreased interaction between the learner and the computer in a LASP learning environment compared to a learner-paced learning environment is why the learner’s gender stereotypes were not apparent? Research has shown that pedagogical agents are seen as conversational partners (Louwerse, Graesser, McNamara, & Lu, 2008) and that they tend to be perceived as more intelligent than they actually are (Kim & Baylor, 2006, p. 573). However, pedagogical agent research has primarily taken place in learner-paced learning environments (Schroeder et al., in press). It is plausible that gender stereotypes are more likely to become apparent in a learner-paced environment due to the increased interaction required to navigate through the learning materials. Alternatively, perhaps learners simply don’t have the time to think about and project gender stereotypes in a LASP environment due to the limited working memory capacity as the individual tries to assimilate all the information being presented. In other words, since the learner-paced system has natural pauses when the learner must press a button to continue, this allows the learner time to reflect and think. Alternatively, a LASP learning environment does not have these features. If the learners want to pause, they must physically hit the pause button. As such, if the learners simply watch the streaming video their working memory may be working at
or near capacity, thus reducing the amount of cognitive resources available to generate and apply gender stereotypes to the agent. Future research can investigate this to see if the pacing of the learning system moderates the perceptions and learning outcomes of pedagogical agents of different genders.

Finally, the results of Experiment Two can extend social cognitive theory. Previous research has found that female pedagogical agents were able to facilitate a learner’s self-efficacy more than a male agent (Baylor & Kim, 2009). Yet, the results of the second experiment show that there were no significant differences found in how pedagogical agents were perceived depending upon their gender. As such, it is apparent that in a LASP learning environment, both male and female pedagogical agents can provide a source of proxy agency, acting as an individual with more knowledge than the learner. Yet, one question still remains: do male or female pedagogical agents provide any advantage to learners with low computer-efficacy? This is plausible due to previous research findings where female pedagogical agents were more effectively able to foster self-efficacy beliefs (Baylor & Kim, 2009), yet it was not possible to examine in this study due to there not being significant differences between groups in their computer-efficacy scores.

As shown, the results from Experiment Two inform the theoretical foundations of its design. Moreover, the results provide many future research directions. In the next section the practical implications of the findings are discussed.

*Practical Implications*

The findings from Experiment Two show that there were not significant differences in how female or male pedagogical agents were perceived by learners, nor were there significant
differences in learning outcome scores. These results are very informative for the teacher-educator and the teacher alike. For instance, when designing a contextually-relevant peer pedagogical agent for a LASP learning environment, the teacher or teacher-educator may encounter the conundrum of whether to select a male or female agent. In terms of fiscal resources, male and female agents may share identical requirements. Yet, the teacher may still ask, which would be more effective for learning? Other studies have found that male pedagogical agents are more effective for fostering learning outcomes than female agents (Moreno et al., 2002), and that male agents are perceived more positively than female agents (Kim, Baylor, & Shen, 2007). However, these findings were not replicated when contextually-relevant peer agents appeared in a LASP learning environment. Thus, if the teacher-educator or teacher is trying to decide which gender of contextually-relevant peer agent to use in their LASP learning environment, they can choose whichever requires fewer resources or they can simply make the decision arbitrarily, as this study shows that the gender of the agent will not affect the learner’s cognitive or affective outcome scores. It is important to note that the gender of an instructor agent may cause changes in how the agent is perceived. Future research should explore the role of an instructor agent’s gender in a LASP learning environment.

Limitations

As with Experiment One, the second experiment is not without its own set of limitations. The two experiments do share one considerable limitation, which is the voice which was used to provide the narration. As mentioned previously, the voice was generated by Xtranormal’s (2012) text-to-speech generator. The male voice in both experiments was identical. However, for the second experiment a female voice was also used. Yet, the female voice suffered from the same limitations as the male voice. As such, there was no control over the speed of the speech, the
inflection, and the voice tended to break apart sentences or pause occasionally. Would the results of Experiment Two have been the same if recorded human voices had been used? Future research can investigate this question.

Another limitation of the second experiment which was due to the Xtranormal (2012) software was the clothing of the agents. The male pedagogical agent was dressed more formally than the female agent. Could this have created a stereotype effect? Was the male agent perceived to be more instructor-like, while the female agent was considered to be more like a peer? Since the appearance of a pedagogical agent can impact a learner’s perceptions and learning (Veletsianos, 2010), could these interpretations have influenced the results? This experiment reiterates calls for research which meticulously examines the visual image of pedagogical agents and the subsequent effects on learner’s cognitive and affective outcomes (Veletsianos, 2010).

Summary

The results from Experiment Two have shown that there was no significant difference between using a male or female pedagogical agent in either learning or perceptive measures within a LASP learning environment. These findings are very important for instructional design, for it takes some of the burden off the designer trying to make an informed decision. Moreover, the findings have raised a few important questions. For example, can manipulating the pacing of a learning system reduce gender stereotype effects when learning with pedagogical agents in a LASP learning environment? Future research should compare the effects of gender stereotypes on cognitive and affective outcomes in both LASP and learner-paced environments to explore this. Another question future research can explore is: does one gender of pedagogical agent teach more effectively for learners of low or high computer-efficacy?
Conclusion

Despite the non-significant findings between groups in both experiments in this dissertation, the results still add important knowledge to the field. For instance, Experiment One showed that a contextually-relevant peer pedagogical agent, when used in a LASP learning environment, can be just as effective for learning as a low verbal redundancy condition. Being that low verbal redundancy conditions have been found to have large effects on learning of $g = .99$ ($p < .05$) when compared to only narration (Adesope & Nesbit, 2012), and pedagogical agents have been found to only have small effects ($g = .19$, $p < .05$) on learning (Schroeder et al., in press), the findings of experiment one speak volumes. These results raise the question: perhaps pedagogical agents can be more effective for learning in a LASP learning environment than in a learner-paced learning environment? Researchers should now focus on exploring more features of the LASP learning environment, including an in-depth analysis of how pedagogical agents should look (Veletsianos, 2010), how intelligent the agent should be, the gestures or actions the agent should perform, and how the pacing of a LASP learning environment can produce different results from traditional system-paced and learner-paced instruction.

As noted, the findings from Experiment Two also did not reveal statistically significant differences between groups for either learning or perceptive outcome scores. However, these findings are not without worth. These results are consistent with some of the limited studies surrounding pedagogical agent gender. Moreover, the findings exemplify how little changes between experiments (i.e. pacing, peer versus instructor agent, type of voice used) can drastically change how effective pedagogical agents are for fostering learners cognitive and affective outcome scores. In the end, the experiment showed that learners do not stereotype contextually-relevant peer pedagogical agents in a LASP learning environment based on their gender in any
meaningful manner. As such, the instructional designer may choose which ever gender of agent is most convenient.

Finally, this dissertation has presented many future research directions. Perhaps the most intriguing are the differences found between this study, which utilized a LASP learning environment, and previous pedagogical agent studies which utilized learner-paced learning environments. The pacing of the LASP learning environment seems to have a number of unexpected effects on cognitive and affective outcomes, as shown by the findings of both experiments. Future research should continue to investigate the LASP learning environment. Particularly interesting are the cognitive load implications. For example, why were participants in Experiment Two not affected by gender stereotypes? Was it a lack of free working memory capacity, or did the agent’s image simply not activate the stereotype schema?

In closing, this dissertation’s findings have added new knowledge to extant theory and practice. However, the primary contributions of this dissertation are the new opportunities for pedagogical agents which have been realized within LASP learning environments. Researchers should continue to explore the bounds of the LASP learning environment, for as of the time of writing, the technologies available to teachers make it easier to implement a pedagogical agent in a LASP learning environment than either a learner-paced or system-paced environment.
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Appendix A. Institutional Review Board Certification of Exemption

MEMORANDUM

TO: Olusola Adesope and Noah Schroeder,

FROM: Patrick Conner, Office of Research Assurances (3005)

DATE: 1/25/2013

SUBJECT: Certification of Exemption, IRB Number 12940

Based on the Exemption Determination Application submitted for the study titled "Exploring Pedagogical Agent use within Learner-Attenuated System-Paced Learning Environments," and assigned IRB # 12940, the WSU Office of Research Assurances has determined that the study satisfies the criteria for Exempt Research at 45 CFR 46.101(b)(2).

This study may be conducted according to the protocol described in the Application without further review by the IRB.

It is important to note that certification of exemption is NOT approval by the IRB. You may not include the statement that the WSU IRB has reviewed and approved the study for human subject participation. Remove all statements of IRB Approval and IRB contact information from study materials that will be disseminated to participants.

This certification is valid only for the study protocol as it was submitted to the ORA. Studies certified as Exempt are not subject to continuing review (this Certification does not expire). If any changes are made to the study protocol, you must submit the changes to the ORA for determination that the study remains Exempt before implementing the changes (The Request for Amendment form is available online at http://www.irb.wsu.edu/documents/forms/rtf/Amendment_Request.rtf).

Exempt certification does NOT relieve the investigator from the responsibility of providing continuing attention to protection of human subjects participating in the study and adherence to ethical standards for research involving human participants.

In accordance with WSU Business Policies and Procedures Manual (BPPM), this Certification of Exemption, a copy of the Exemption Determination Application identified by this certification and all materials related to data collection, analysis or reporting must be retained by the Principal Investigator for THREE (3) years following completion of the project (BPPM 90.01). This retention schedule does not apply to audio or visual recordings of participants, which are to be erased, deleted or otherwise destroyed once all transcripts of the recordings are completed and verified.

You may view the current status or download copies of the Certified Application by going to https://myresearch.wsu.edu/IRB.aspx?HumanActivityID=37103
Washington State University is covered under Human Subjects Assurance Number FWA00002946 which is on file with the Office for Human Research Protections (OHRP).

Review Type: New
Review Category: Exempt
Date Received: 1/10/2013
Exemption Category: 45 CFR 46.101 (b)(2)
OGRD No.: N/A
Funding Agency: N/A

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Appendix B. Instructional monologue.

Hey, so I heard from a friend that you were interested in how to teach more effectively with technology. I don’t blame you, technology can be fun to use and if it’s used effectively, it can be a great teaching tool. There are quite a few things you should keep in mind to keep your teaching with technology simple and effective. One thing that is particularly important to understand is cognitive load theory. Basically the theory says that there are two types of memory, the working memory and long-term memory. The working memory is pretty small and can only handle small amounts of information at a time, but the long-term memory is nearly limitless. The long-term memory contains everything you’ve ever learned, and is organized by things called schema. The brain is able to function because the working memory takes in new information and finds an appropriate schema to store it in. If there isn’t one, it makes a new schema for the information. That way if the long-term memory needs to find information, it just finds the schema the information is stored in.

Cognitive load theory also describes three types of additive mental load. Extraneous cognitive load is the extra strain put on the brain which doesn’t relate to the learning material itself. For example, a poorly designed presentation can cause extraneous cognitive load. This can be bad for learning. Intrinsic cognitive load is due to the nature of the learning material. While it can be different for each student, it’s the mental load due to learning the specific information being learned. Germane cognitive load is a little bit different, because it is due to the construction of schemas.

When you design your presentations, you also need to think about the split-attention principle and the modality principle. The split-attention principle basically says that if you make
the student pay attention to more than one thing at once, it might interfere with their learning. For example, if you put a diagram on the screen and have the text that goes along with it off to the side, or on a separate sheet entirely, it may decrease learning. To get around this, you can present the information in an integrated format. In other words, the diagram and the supporting information should all be presented together in one location, such as a labeled diagram.

The modality principle is a bit different. It says that some information should be presented visually, while some information is presented through narration. This allows the student to bring in the maximum amount of information possible, using both their eyes and ears. For example, if you were teaching students about ecosystems, you could show a picture of an ecosystem, and then describe the ecosystem to the students verbally.

As you can see, using multimedia effectively isn’t really that hard, it just takes some planning. I’m sure that with a little bit of practice, you’ll get really good at teaching with technology. Anyway, I gotta go, but good luck on your next teaching assignment!
Appendix C. Demographic Questionnaire.

1. My experiment ID number is: ___________

2. Are you male or female?
   a. Male
   b. Female

3. How old are you? __________

4. My ethnic background is/are (choose one or more)
   a. African
   b. African-American
   c. Asian
   d. Caucasian
   e. Hispanic
   f. Native American
   g. Other (please specify)

5. My first language is: ________________________

6. I have completed ______ years of postsecondary education.

7. Have you ever had formal instruction concerning multimedia learning theory?
   a. Yes
   b. No

8. I use multimedia or software presentations when I teach:

   1 - - - - 2 - - - - 3 - - - - 4 - - - - 5

   never                        almost always
Appendix D. Computer-efficacy Scale

This scale is an adapted version of what appears in Compeau and Higgins (1995).

Introduction (adapted from Compeau & Higgins, 1995):

Often when teaching we are told about software packages that are available to make our lives easier. For the following questions, imagine that you were given a new software package for some aspect of your teaching. It doesn't matter specifically what this software package does, only that it is intended to make your job easier and that you have never used it before.

The following questions ask you to indicate whether you could use this unfamiliar software package under a variety of conditions. For each of the conditions, please indicate whether you think you would be able to complete the job using the software package. Then, please rate your confidence about your first judgment, by circling a number from 1 to 10, where 1 indicates "Not at all confident," 5 indicates "Moderately confident," and 10 indicates "Totally confident."

I could teach using the software package…

1. If there was no one around to tell me what to do as I go.
2. If I had never used a package like it before.
3. If I had only the software manuals for reference.
4. If I had seen someone else using it before trying it myself.
5. If I could call someone for help if I got stuck.
6. If someone else had helped me get started.
7. If I had a lot of time to complete the job for which the software was provided.
8. If I had just the built-in help facility for assistance.
9. If someone showed me how to do it first.
10. If I had used similar packages before this one to teach.
Appendix E. Pre-test questionnaire.

Questions

1. In three sentences, please write what you know about cognitive load theory.

2. In two sentences, please write what you know about the split-attention principle.

3. In two sentences, please write what you know about the modality principle.
Appendix F. Post-test questionnaire.

*Free Recall*

1. Please write down everything you can remember about the theories and principles of teaching with technology from the video you just watched.

*Multiple Choice*

*correct answers appear in bold*

1. According to cognitive load theory, what are the two types of memory?
   a. Working memory and permanent memory
   b. Temporary and long-term memory
   c. **Working memory and long-term memory**
   d. Short-term memory and long-term memory

2. According to cognitive load theory, what are the three types of mental load?
   a. **Intrinsic, extraneous, and germane**
   b. Germane, intrinsic, and normal
   c. Intrinsic, extraneous, and normal
   d. Germane, extraneous, and intricate

3. What does the split-attention principle state?
   a. Learning may be facilitated by presenting information separately
   b. **Learning may be facilitated by presenting information in an integrated format**
   c. Learning may be facilitated by having the student split their attention between two information sources
d. Learning may be facilitated by providing some information aurally while other information is presented visually.

4. What does the modality principle state?
   a. Learning may be facilitated by providing some information aurally while other information is presented visually.
   b. Learning may be facilitated by providing all information aurally
   c. Learning may be facilitated by providing all information visually
   d. Learning may be facilitated by providing some information on a piece of paper, while the rest is presented on a blackboard or computer screen.

5. What is a schema?
   a. A measure of cognitive load
   b. A technology tool used to present information to a student
   c. An organizational structure in the brain
   d. An organizational structure within a classroom

6. Which of the following demonstrates instruction which is taking advantage of the modality principles effects?
   a. The teacher provides three handouts to the students to read while showing a diagram on the board.
   b. The teacher provides a picture on the board while describing it verbally.
   c. The teacher provides three handouts to the students to work on in small groups
   d. The teacher provides a picture on the board as well as a handout with text describing the picture.
7. Which of the following demonstrates instruction which is influenced by the split-attention principle?

   a. The teacher provides two handouts to students and describes them verbally.
   b. The teacher verbally describes what the students are seeing on the board.
   c. The teacher provides a handout while putting additional text on the board.
   d. The teacher provides a handout which has the graphics and text integrated.

8. When teaching with technology, you should try to:

   a. Maximize the students extraneous cognitive load
   b. Maximize the students intrinsic cognitive load
   c. Increase the overall cognitive load of the assignment.
   d. None of the above.

9. If a teacher verbally describes a picture which was shown to students, then they are utilizing the beneficial effects of the:

   a. Presence Principle
   b. Modality Principle
   c. Split-attention principle
   d. Cognitive Load principle

10. If a teacher integrates a diagram and its relevant text, then they are making an effort to follow the:

    a. Split-attention principle
    b. Cognitive Load Principle
    c. Modality Principle
    d. Presence Principle
11. A teacher draws a diagram on the board in their geometry class. The angles needed to solve for the missing angles are labeled within the diagram. In this instance, the teacher has utilized which principle of multimedia learning?
   a. Cognitive Load Principle
   b. **Split-attention Principle**
   c. Extraneous Load Principle
   d. Modality Principle

12. The schema are used to organize the:
   a. Short-term memory
   b. Working memory
   c. Permanent Memory
   d. **Long-term memory**

13. Which part of the brain brings in new information?
   a. Schema
   b. **Working Memory**
   c. Short-term memory
   d. Long-term memory

14. What causes germane cognitive load?
   a. The working memory
   b. Poor instructional design
   c. **The construction of schema**
   d. The nature of the material being learned
15. The inherent complexity of the material being learned causes what type of cognitive load?
   a. Extraneous
   b. Extrinsic
   c. Germane
   d. Intrinsic

16. What can cause extraneous cognitive load?
   a. Poor instructional planning
   b. Too many things going on in the learning environment
   c. Too many seductive details to distract the learner
   d. All of the above

17. The three types of cognitive load are:
   a. Additive, where each type of load puts more strain on the memory resources
   b. Subtractive, where germane cognitive load is subtracted from intrinsic cognitive load to utilize more memory resources.
   c. Subtractive, where germane cognitive load is subtracted from extraneous cognitive load to utilize more memory resources.
   d. None of the above, each construct is independent.

18. The split-attention principle tries to reduce:
   a. Intrinsic cognitive load
   b. Extraneous cognitive load
   c. Germane cognitive load
   d. Inherent cognitive load
19. Intrinsic cognitive load may be:
   a. Influenced by extraneous cognitive load
   b. Different depending upon extraneous cognitive load
   c. **Different for each student**
   d. Influenced by the way the material is presented to the student

20. By utilizing the modality and split-attention principles in your lesson plan, you may be able to:
   a. **Facilitate student learning**
   b. Increase cognitive load
   c. Increase student motivation
   d. Increase the cognitive processing time of each piece of information

21. Students may learn more if you can:
   a. Increase the cognitive load caused by the lesson
   b. **Decrease the cognitive load caused by the lesson**
   c. Increase the modality of the lesson
   d. Decrease the modality of the lesson

22. A teacher is lecturing in class about a battle in the Civil War. The students each have a handout which contains photos of battle uniforms as well as a photograph of the modern battlefield. The teacher asks the students to cut out the two types of uniforms and put them on the correct sides of the battlefield. This teacher’s lesson plan has not abided by the:
   a. Cognitive load theory
   b. **Cognitive load principle**
c. Modality principle

d. Split-attention principle

23. A college professor puts a large section of text on the board accompanied by a large picture. If the professor had read the text aloud instead, this approach would have taken advantage of the effects of which principle?

a. The cognitive load principle

b. The modality principle

c. The split-modality principle

d. Germaine cognitive load

24. A teacher notices that one student in their class is struggling with the learning material a lot more than the other students. This student may be encountering greater levels of ________ than other students.

a. Inherent cognitive load

b. Intrinsic cognitive load

c. Implicit cognitive load

d. Intricate cognitive load

25. A teacher notices that when reading a textbook, the students frequently have their attention split between the text and the pictures. This is likely causing:

a. Intrinsic cognitive load

b. Germaine cognitive load

c. Inherent cognitive load

d. Extraneous cognitive load
26. A student is working on a multiplication worksheet and obviously is struggling. When asked what is so hard, the student replies, “I am just not good at multiplying by 7.” In this case, the ________ cognitive load is high for the student.

   a. Intrinsic  
   b. Germane  
   c. Extraneous  
   d. Schema  

27. Which of the following takes advantage of the split-attention principles effects?

   a. Presenting a picture on the board while handing out a text description.  
   b. Presenting a picture on the board while verbally describing the image.  
   c. **Presenting a picture with the pertinent items labeled directly on it.**  
   d. Presenting a picture with the pertinent items labeled off to the side.  

28. A teacher brings a group of students to an aquarium. While they’re looking at different types of fish, the teacher describes each species as it swims by. This teacher is utilizing the beneficial effects of the ______________

   a. Split-attention principle.  
   b. Cognitive load principle  
   c. **Modality principle.**  
   d. Demonstration principle.

29. A teacher decides they want to implement the modality principle in their teaching. In order to do so, they are going to emphasize:

   a. Presenting most information visually.  
   b. Presenting information through auditory forms.
c. Presenting information in an integrated format.

d. **Presenting information through both visual and auditory forms.**

30. A student reads a text and comprehends the information. However, when the same information is presented to the student through a multimedia presentation, they find it confusing. The presentation is likely causing:

a. **Extraneous cognitive load.**

b. Intrinsic cognitive load.

c. Germane cognitive load.

d. None of the above.

*Transfer Question*

In a few sentences, briefly describe a lesson you could teach which would utilize cognitive load theory, the split-attention principle, and the modality principle. Be sure to explain how your lesson addresses these theories.

*Agent Persona Instrument* (from Ryu & Baylor, 2005)

**Facilitating Learning** (10 items)

The agent led me to think more deeply about the presentation.

The agent made the instruction interesting.

The agent encouraged me to reflect what I was learning.

The agent kept my attention.

The agent presented the material effectively.
The agent helped me to concentrate on the presentation.

The agent focused me on the relevant information.

The agent improved my knowledge of the content.

The agent was interesting.

The agent was enjoyable.

**Credible** (5 items)

The agent was knowledgeable.

The agent was intelligent.

The agent was useful.

The agent was helpful.

The agent was instructor-like.

**Human-like** (5 items)

The agent has a personality.

The agent’s emotion was natural.

The agent was human-like.

The agent’s movement was natural.

The agent showed emotion.
Engaging (5 Items)

The agent was expressive.

The agent was enthusiastic.

The agent was entertaining.

The agent was motivating.

The agent was friendly.