ABSTRACT

BEHREND, TARA SHETYE. Participation in Pedagogical Agent Design: Effects on Training Outcomes. (Under the direction of Lori Foster Thompson.)

Pedagogical agents have the potential to increase engagement and learning for trainees completing e-learning courses. However, little research to this date has been conducted to determine the conditions that make these agents most effective. The current study examined the role of agent design control in improving learner reactions and learning. A sample of 164 e-learners completed a Microsoft Excel training course; half of the learners were given the opportunity to design a pedagogical agent that suited their preferences, while the others were assigned an agent with predetermined features. Those who helped design their agent were randomly assigned to one of four conditions which allowed them to participate in the configuration of their agent's (a) appearance, (b) personality, (c) feedback style, or (d) all of the above. Findings demonstrated that participation influenced scores on a post-training declarative knowledge test, although this effect depended on the type and amount of participation permitted. Specifically, feedback participation decreased declarative knowledge, while participation in multiple agent characteristics increased declarative knowledge. Contrary to expectations, participation regarding agent feedback also decreased utility reactions and self-efficacy. No type of participation influenced affective reactions or engagement. Although some forms of participation yielded trends in the expected direction, effects were not statistically significant. On the whole, this study expands the learner control literature, identifying a new form of learner control that has beneficial effects on knowledge acquisition.

Participation in Pedagogical Agent Design: Effects on Training Outcomes

by

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BIOGRAPHY

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My husband Dan reminds me every day what it means to be a good person. I thank him for sharing his life with me.

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Participation in Pedagogical Agent Design: Effects on Training Outcomes

Today's increasingly virtual world of work prompts a critical need for research designed to maximize the usefulness of web-based training. Intelligent agents (i.e., pedagogical agents) are a potentially viable mechanism for engaging and motivating trainees; however, there is still much to be learned about the factors that shape the effectiveness of intelligent agents during training. The purpose of this study was to examine whether giving e-learners the opportunity to customize and participate in the design of a pedagogical agent influences important training outcomes[1].

Virtual Training

Relative to more conventional alternatives such as classroom training, e-learning has a number of advantages. For example, e-learning can provide beneficial features that are not easily replicable in traditional classroom settings, such as immediate individualized feedback (Kulik & Kulik, 1988; Phye & Andre, 1989). *Learner control* is also a major advantage of e-learning, and has been found to improve engagement and other learning outcomes (Kraiger & Jerden, 2007).

One drawback is that certain aspects of learner control which make e-learning attractive, such as greater flexibility and customization, may have negative consequences. Left to their own devices, learners are not always motivated or engaged enough to devote sufficient time and attention to their training. E-learners are required to make many decisions

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[1] The proposal upon which this research was based in presented in Appendix A.

about what to learn and how, and this can result in a high proportion of skipped content, or high dropout rates. These suboptimal learner choices (e.g., skipping important material) may decrease learning outcomes (Brown, 2001).

Thus, although learner control is often touted an important advantage of computer-based training (Clark & Mayer, 2008; Kraiger & Jerden, 2007), it can have positive or negative effects, depending on the choices learners make. This suggests a need to better understand learner control in order to effectively incorporate it into training. One potentially fruitful research avenue entails exploring alternative participation mechanisms which allow e-learners to control aspects of their training design which do not influence their degree of exposure to the material (e.g., *design control*, DeRouin et al., 2004).

Intelligent agents have potential to increase engagement and reduce isolation by acting as peers, or personal tutors. As discussed next, providing for learner control over the design of an agent may prompt some of the positive effects of learner control while minimizing the negative effects.

Intelligent Agents

An intelligent agent is a software application that gathers information from users and then delivers customized content and/or services (Bonett, 2001). Intelligent agents are used in a wide variety of educational, organizational, and commercial settings. Animated pedagogical agents (APAs) are a specific class of agents that are represented as a human or animal body within the virtual environment, designed to facilitate learning (Baylor & Kim, 2005). APAs can be used in a variety of learning settings, and can be programmed to fill a number of diverse roles; for example, an APA may act as a tutor, instructor, coach, or peer

(Lee et al., 2007). Researchers in the educational domain have begun to study the effects of these agents on learners. From these studies, it is clear that the presence of an agent can sometimes improve learner engagement and motivation, although these effects may depend on the features of the agent itself. However, it is important to note that very few studies have given learners explicit choices to make regarding the agent. That is, although researchers have examined the effects of a wide range of agent characteristics, the characteristics are typically fixed for a particular learner. Learners have seldom been given control over the appearance or behavior of the agent.

Effects of Agents on Learners

Previous studies measuring the effect of agents on learners have shown that the mere presence of an agent sometimes increases enjoyment. For example, Berry, Butler, and DeRosis (2005) compared the effects of an animated agent named GRETA who delivered information about healthful eating to the effects of the same information delivered in plain text or read by a human actor. Results demonstrated that GRETA was rated as more helpful than voice or text only. However, this effect is not always found; sometimes users report that a non-agent activity is more entertaining and enjoyable than the same activity with an agent (Den & van Mulken, 2000).

Similarly, agents may have effects on learning, although these effects are not entirely understood. Proponents of pedagogical agents claim that the presence of an agent leads to higher engagement, which in turn causes learners to retain more of the material (Lester & Stone, 1997). Other researchers claim that the agent merely distracts the learner from the material, and that simpler instructional design features accomplish the same goals an agent is

intended to accomplish (e.g., providing feedback, introducing material, etc; Choi & Clark, 2006). For example, Choi and Clark (2006) compared an animated agent to an arrow that pointed to relevant information, both accompanied by a voice, and found no differences in 300 middle school students' learning of an English grammar lesson. Choi and Clark (2006) note that "although students may enjoy their interaction with an agent, it does not mean they will learn better" (p.444).

A third position on the matter is more nuanced, suggesting that the effects of agents are not universal, but depend on the specific features of the agent in question (Kim & Baylor, 2005). In accordance with this view, researchers have moved past the simple comparison of agent-based training and non-agent-based training, to explore the specific characteristics of agents that may contribute to their effectiveness. Some of these characteristics include the agent's appearance (e.g., Baylor & Kim, 2004), expression of empathy (e.g., McQuiggan & Lester, 2007), embodiment (e.g., Lee et al., 2006), animation (e.g., Craig, Gholson, & Driscoll, 2002), personality (Isbister & Nass, 2000), or manner of delivering feedback (e.g., Kim, Baylor, & Shen, 2007). An overview of some of the more frequently examined agent characteristics, namely appearance, personality, and feedback style, is presented next.

Frequently Studied Agent Characteristics

Appearance. There is some evidence that learners are more likely to rely on advice from an agent whose ethnicity is similar to their own. Pratt et al. (2007) matched adult learners with either a Caucasian or African-American computer agent, and found that learners changed their opinion to be consistent with agent advice to a greater degree when matched with a same-ethnicity agent. These findings are also consistent with Lee and Nass

(1998), who found that same-ethnicity agents were rated as more attractive and more trustworthy than different-ethnicity agents.

Researchers have also studied other aspects of agent appearance. For example, Kim et al. (2007) examined the effect of agent gender. Students who worked with a male agent on a computer literacy task showed significantly higher interest in the task and in working with the agent than did students working with a female agent. Further, students who worked with the male agent scored higher on a test of recall. However, the researchers did not include participant gender in their analyses, so it is unclear whether this effect was found for all learners.

Thus, it seems that agent appearance can affect learners, although the nature of the appearance-outcomes relationship may depend on the learner. Some learners may work better with agents that look similar to themselves, or may prefer an agent of a particular gender. Gulz (2005) demonstrated that learners are able to articulate preferences for particular agent characteristics; further, the author argues that flexibility be built into agent design in order to accommodate these learner preferences.

Feedback Style. Lester, Converse, Stone, Kahler, and Barlow (1997) examined the effects of various feedback types on student performance, comparing five versions of an animated bug named Herman that varied in the degree and type of feedback they delivered. Results showed that the type of feedback delivery offered had differential effects on student learning.

Building on this finding, researchers have examined other types of feedback behavior. Kim et al. (2006) compared a proactive agent (i.e., an agent that offered advice before being

asked to do so) to a responsive agent (i.e., an agent that waited for the user to ask for help). In their study, the agent was framed as a computerized peer who was learning along with the participants (i.e., a learning companion). Students who worked with the proactive learning companion had significantly higher scores on a recall test, but did not do any better on a test of application. Additionally, feedback style had no effect on learner attitudes toward the agent. The reason for this finding may be that certain types of learners preferred different feedback styles; students in this study, as well as Lester et al.'s (1997) study, were assigned to receive a particular type of feedback and were not permitted to choose the feedback type that best suited their preferences.

Wang et al. (2008) provided evidence that individual differences may explain variation in preferences for a particular type of feedback. Wang et al. found that students who interacted with a polite agent scored higher than those who interacted with an impolite agent on a multiple-choice knowledge test. Importantly, they found that this effect was particularly strong for more extraverted students and students who were relatively high in need for cognition. Interestingly, no overall differences were found between students who worked with the impolite agent, compared with the polite agent, in student's level of liking for the agent, interest in the task, or desire to work with the agent again. As noted previously, this lack of results could be due to different types of learners preferring different types of feedback.

Personality. Finally, researchers have attempted to identify personality characteristics that may be more or less appealing to users. Nass et al. (1995) matched dominant[2] or submissive users with either dominant or submissive computers. Users preferred to work with computers that matched their own personalities, rated matched computers as more intelligent, and were more likely to listen to the matched computers' than the unmatched computers' suggestions. No main effect of computer "personality" was found; that is, there was not a single computer personality that was preferred overall. Similarly, Nass and Lee (2001) discovered that introverted users found a computerized voice more attractive when it signaled an introverted personality compared to an extraverted personality; further, they were more likely to rate the voice as credible and were more likely to act on its recommendations (i.e., purchase a recommended book). The same pattern was observed for extraverted users; that is, users more often preferred to listen to a computer voice that matched their own personality.

In sum, although a wide range of outcomes have been examined, no clear consensus has emerged regarding the most effective agent design characteristics for increasing learning and engagement. One possible reason for this lack of consensus is that the most effective type of agent depends on a user's unique preferences. As mentioned previously, agent characteristics are typically fixed for a given learner, eliminating the possibility of learner control over the interaction. For example, one learner may wish to work with an agent that offers a great deal of feedback, while another may prefer to be "left alone." People may learn

[2] Dominance is a facet of the California Personality Inventory that roughly corresponds to the Assertiveness subfacet of extraversion in the NEO-PI.

best from an agent that shares their personality traits, or one that they feel comfortable with. Because we know that user preferences for different agent characteristics vary, it makes sense to allow users to choose the type of agent they will interact with. Giving users control over the design of an agent is one way to increase the chances that they will like their agent and feel comfortable with it. As discussed next, there is a strong theoretical basis for the benefits of participation, which are central to the hypotheses and research questions proposed in this study.

Theoretical Foundation for the Effects of Participation

The ability to exert control over one's environment has been described as a basic human need (Langer, 1975; Kelley, 1971; Mischel, Cantor, & Feldman, 1996). Researchers normally agree that control is important for general well-being as well as more specific outcomes such as job satisfaction (Ganster & Fusilier, 1989; Troup & Dewe, 2002) and work stress (e.g., Demand Control Model; Karasek, 1979). Participation also tends to have positive effects on user acceptance of new technology (Coovert & Thompson, 2003).

There are several theoretical reasons why participation in the design of pedagogical agents should have beneficial effects for trainees. First, participation may improve training outcomes due to its effects on intrinsic motivation. Self determination theory (Deci & Ryan, 1985, Ryan & Deci, 2000) proposes that three basic human needs are at the foundation of individuals' self-motivation and fulfillment: the need for competence, the need for relatedness, and the need for autonomy. Individuals will be intrinsically motivated to the extent that these needs are met. Providing choice is thought to increase a person's sense of both autonomy and competence, and thus their intrinsic motivation (Deci & Ryan, 1985).

Second, learners will be more likely to believe that their agent is useful if they themselves have designed it, regardless of the actual quality of the agent. This argument is consistent with cognitive dissonance theory (Festinger, 1957), which predicts that if learners invest the effort required to design an agent, they will be motivated to believe the agent is useful in order to justify the effort expended. Indeed, past research has demonstrated that people often report liking an object more simply because they have chosen it (e.g., Snibbe & Markus, 2005).

Finally, learners may intentionally or unintentionally create tutors that are similar to themselves with regard to appearance or personality. The similarity-attraction paradigm (Byrne & Nelson, 1965) predicts that if learners interact with agents that are similar to them, they will be more likely to enjoy their interaction, and report liking the agent, than if they interact with dissimilar agents.

Effects of Participation in Agent Design

While theory suggests that participation in the design of a pedagogical agent may have a number of beneficial effects for learners, controlled research testing this supposition is needed. Meta-analytic studies examining the effects of learner control in (non-agent) e-learning have demonstrated that control over the pace or sequence of material has a positive effect on learner motivation and reactions (Kraiger & Jerden, 2007); however, very little research has examined the effect of learner control over pedagogical agent characteristics.

One notable exception is a 2006 study conducted by Moreno and Flowerday, who empirically tested several aspects of learner choice with respect to agent design, namely agent image, ethnicity, and gender. The researchers predicted that choice would improve

reactions to the agent (as measured by helpfulness, motivation, and difficulty ratings). Choice was not found to impact learning, nor was there an interaction between choice and the gender/ethnicity similarity between the learner and agent. Similarly, no difference was found between the choice and no choice group with regard to program ratings, which the researchers assessed with a combination of five items measuring agent helpfulness, desire to use the agent in the future, and training difficulty.

Moreno and Flowerday (2006) believe that this pattern of findings is due to the added distraction introduced by allowing learners to choose an agent. They noted, "When students choose to learn with an APA of their same ethnicity, they focus their attention on how the APA represents them rather than on the instructional materials themselves" (p. 204). While this may explain the lack of effect for learning outcomes, it does not explain the lack of effect for the reactions measure. Perhaps, instead, this lack of effect was methodological; the researchers assessed reactions with only a few items, leaving open the possibility that the constructs were not adequately captured. The researchers used two items to measure helpfulness, one to measure desire for future interaction, and two to measure perceived training difficulty. No theoretical rationale was included for these measures, nor was reliability or validity information presented.

Another limitation to the Moreno and Flowerday (2006) study is that participants were only allowed to control superficial characteristics related to the agent's appearance. Perhaps control over other aspects of the agent, such as its personality, would yield different results. Finally, the authors failed to control for the effects of the choices made by participants. Participants who were not able to choose their agent's ethnicity or gender were

randomly assigned to an agent. This created a confound between choice and agent type, with participants in choice and non-choice conditions interacting with potentially different kinds of agents. Based on these limitations, the effect of choice in pedagogical design warrants further research employing alternative methods and measures to examine the phenomenon at hand.

Study Hypotheses

The current study will examine the effects of providing learners with participation into the design of their pedagogical agent, focusing on three characteristics that are frequently examined in the literature: appearance (gender, ethnicity), personality (empathy, humor), and feedback-giving behavior (directiveness, normativeness[3]). A number of outcomes or criteria can and should be examined to determine the effects of participation on agent acceptance. Thus, a variety of training outcomes were examined in this study. These outcomes, which are detailed in the following section, include trainee reactions (affective, utility, and engagement) as well as learning (post-training self-efficacy and declarative knowledge). Further, individual differences in desire for control were explored as a moderator of the effects of participation on these outcomes. Figure 1 presents the model guiding this research.

Training Reactions. Reactions are trainees' attitudes toward the training, including both affective and utility components. *Affective* reactions refer to the degree to which trainees enjoyed themselves during training, whereas *utility* reactions refer to the trainee's cognitive

[3] Directive feedback refers to feedback that *tells* learners what to do next, rather than *suggests*; normative feedback refers to feedback that gives learners information about where they stand in relation to other learners.

assessment of whether the training was useful to them (Alliger, Tannenbaum, Bennett, & Trayer, 1997). Finally, *engagement* has recently been included in assessments of trainee reactions as well (e.g., Brown, 2005). Engagement refers to the degree to which the training system holds trainees' attention throughout training. Engaged learners report being highly absorbed and immersed in the training tasks (Garris, Ahlers, & Driskell, 2002). Together, these three components of reactions can be thought of as the degree to which learners believe they have had a meaningful and satisfying learning experience (Sitzmann, Brown, Casper, Ely, & Zimmerman, 2008).

Trainee reactions are important outcomes of training for several reasons. First, trainees' attitudes about the training are likely to influence the probability that they will enroll in future courses, as well as the general reputation of the training program in an organization. These factors are typically of great interest to organizational decision-makers. Second, positive affect during training is associated with greater motivation, interest, and enthusiasm (Brown, 2005), all of which may facilitate the learning process.

Learner control is purported to improve affective reactions, as well as willingness to attend additional training and intrinsic motivation (Kraiger & Jerden, 2007). Research regarding student attitudes has demonstrated that providing students with choices in their education results in higher intrinsic motivation and more positive attitudes about school (Weinert & Helmke, 1995). With regard to utility reactions, it should be noted that the work of Nass et al. (1995) and Nass and Lee (2001) supports the assertion that users will view agents as more credible and intelligent when they are similar to themselves than when they are different from themselves. Thus, from a similarity perspective, participation should have

a positive effect on utility reactions. Additionally, participation should prompt internal regulation (i.e., intrinsic motivation). Internal regulation is often associated with higher engagement and satisfaction (Deci & Ryan, 2006).

In light of the prior research and theory related to learner choice and control, participation in the design of a pedagogical agent was expected to improve training reactions, including affective reactions, utility reactions, and engagement.

Hypothesis 1: Participation in the design of a pedagogical agent's (H1a) appearance, (H1b) personality, and (H1c) feedback style will improve affective training reactions.

Hypothesis 2: Participation in the design of a pedagogical agent's (H2a) appearance, (H2b) personality, and (H2c) feedback style will improve utility training reactions.

Hypothesis 3: Participation in the design of a pedagogical agent's (H3a) appearance, (H3b) personality, and (H3c) feedback style will improve engagement.

Learning. The question of whether agents facilitate learning is fundamental, as the attainment of new knowledge and skills is one of the principal reasons why most training programs exist. Learning is a multidimensional outcome of training, and encompasses cognitive, skill-based, and affective constructs (Kraiger, Ford, & Salas, 1993). Cognitive learning outcomes include declarative knowledge (i.e., statements of fact) and procedural knowledge (i.e., knowledge about how to perform a skill). Skill-based learning outcomes assess the fluidity and automaticity with which a person can perform a skill. Finally, affective learning includes attitudinal and motivational outcomes such as self-efficacy (Kraiger, Ford, & Salas, 1993). A given training program will typically focus on a subset of learning

outcomes, depending on the nature of the training. The present study assessed both cognitive and affective learning outcomes.

With regard to cognitive learning, a meta-analysis of the relationship between learner control and learning in a non-agent training context showed that in general, learner control has a positive but small effect (Kraiger & Jerden, 2007). Learner control is more likely to result in improved learning when the outcomes are skill-based (rather than knowledge-based). The effect of learner control also appears to be more pronounced for learners with little prior experience with the subject matter. The type of control offered to learners is also a moderator; pace and sequence control tend to have positive effects on learning while content control does not.

Adding to these mixed results, there is inconsistent theoretical and empirical evidence for the idea that participation in the design of a pedagogical agent improves learning. Learner control has typically been shown to increase reactions (Kraiger & Jerden, 2007). Positive reactions during training may then lead to learning gains, as learners become more engaged with the material and devote more energy to learning (Brown, 2005; Sitzmann et al., 2008). Thus, if participation increases intrinsic motivation, and increases reactions, it may increase learning as well. This claim is supported by meta-analytic research by Brown (2005), who argued that the positive affect that comes from an enjoyable training experience will cause trainees to devote more time to training, thus leading to more learning.

However, despite these claims, most studies on the effects of participation have not been able to demonstrate an effect on learning. Schraw, Flowerday, and Reisetter (1998) examined the effect of choice on reading comprehension. Students in the choice group were

permitted to select one of three texts they wished to read, while students in the denied-choice group were assigned a text. Although those in the choice group reported more interest in the text and more satisfaction with the research experience, the two groups did not differ on measures of cognitive performance (including a multiple-choice test of main ideas and essays included in the text). Similarly, Moreno and Flowerday (2006) found that choice over an agent's gender and ethnicity did not improve cognitive learning outcomes; in fact, learning was negatively affected by choice in some cases.

The mixed result obtained by Moreno and Flowerday (2006) lends credence to the assertion that offering learners too many choices may actually detract from cognitive learning. The *interference principle* states that under some circumstances, learners might direct their limited cognitive resources to an agent instead of the material being trained. Although some view choice as a positive influence that leads to intrinsic motivation, others note that there are downsides to choice. For example, Iyengar and Lepper (2000) found that exposure to too many choices in a consumer setting discouraged purchase behavior[4]. Katz and Assor (2007) note that adding "seductive details" (i.e., entertaining but irrelevant sentences) to training may actually hurt student retention of the material, due to the additional demands placed on the student's working memory. More to the point, giving trainees too many choices regarding the appearance and behavior of a pedagogical agent may serve to distract them from the actual content of the training material if their attention is unduly directed towards the outcome of their choices during the training (e.g., a learner who

[4] Despite their decreased purchase behavior, participants in that study reported greater enjoyment of the task when they had more options, even though they found it more difficult.

chooses an extraverted agent may look for instances of extraverted behavior to confirm the choice made). Ryan and Deci (2006) concede that too many choices can serve to detract from self determination, noting, "…choice can, when meaningful, facilitate self determination, especially when it allows one to find that which one can wholeheartedly endorse. But choice can be constructed to do nothing of the sort, instead engendering confusion or fatigue" (p. 1577).

In short, there exist contradictory views on how agent design participation should affect learners' attention to the training material. Consequently, specific predictions concerning the effect of agent design participation on cognitive learning are difficult to justify. This issue was explored here in the form of research questions in hopes of shedding light on the phenomenon. In addition to simply looking at the presence of a participation opportunity, the effects of the amount/degree of participation in pedagogical agent design were examined. This tested the concern regarding the potentially detrimental effects of participation overload.

Research Question 1: How does participation in the design of a pedagogical agent's (RQ1a) appearance, (RQ1b) personality, and (RQ1c) feedback style influence cognitive learning?

Research Question 2: Does increasing the amount of participation in pedagogical agent design change the effect of participation on cognitive learning?

In contrast to cognitive learning, the anticipated effects of participation on affective learning outcomes such as post-training self-efficacy are more straightforward. Self-efficacy (Bandura, 1986) is the subjective assessment that one has the internal and/or external

resources to cope with a given or hypothetical situation. In a training context, self-efficacy is often conceptualized as the confidence trainees have that they can successfully use the knowledge they obtained in training while on the job (Sitzmann et al., 2008). In other words, self-efficacy can be thought of as a measure of one's perceived ability to apply what he or she has learned. Sitzmann et al.'s meta-analysis demonstrated that post-training self-efficacy is the most useful self-report outcome in terms of predicting learning, especially procedural knowledge and delayed procedural knowledge (i.e., assessments conducted after some time period has passed).

As suggested previously, participation is believed to fulfill learners' need for competence. In other words, providing learners with participation opportunities sends the message that that they are capable of making effective choices in their own learning. Keller's (1983) model of motivational instructional design incorporates this idea, proposing that learner control enhances students' self-efficacy. Chou and Liu (2005) found empirical support for this idea, demonstrating that students in a learner-controlled training environment (i.e., students could choose the time and location that they completed assignments) developed higher post-training self-efficacy than students in an identical course without learner control over time and location. Based on this theoretical and empirical evidence, agent design participation is expected to increase self-efficacy.

Hypothesis 4: Participation in the design of a pedagogical agent's (H4a) appearance, (H4b) personality, and (H4c) feedback style will increase post-training self-efficacy.

Desire for Control. A user's individual preference for having control is expected to moderate the relationship between participation and training outcomes. According to Kraiger

and Jerden (2007), individual preferences for control moderate the effect of learner control on training outcomes: "Trainees who experience a level of control that corresponds to their preferred level will enjoy training more, engage in training longer, and be more likely to take more training in the future than trainees who receive too much or too little control" (p. 82). This proposition remains to be empirically tested; further, it refers to learner control over the pace, navigation, or content of the training, rather than control over the design of an agent.

In the social psychological literature, this preference for having control is referred to as *desire for control* (DC; Burger & Cooper, 1979), defined as "the individual differences in the general level of motivation to control the events in one's life" (Burger & Cooper, 1979, p. 381). Burger and Cooper theorized that these individual differences in people's motivation to be in control are related to motivations to feel masterful and competent. Thus, high-DC individuals are expected to be more reactive to the effects of participation opportunities.

Hypotheses 5-8: Desire for control moderates the effects of participation on affective reactions (H5), utility reactions (H6), engagement (H7), and post-training self-efficacy (H8), such that a high desire for control strengthens the positive effects of participating in the design of a pedagogical agent's (a) appearance, (b) personality, and (c) feedback style.

Research Question 3: Does desire for control moderate the effects of participation on declarative knowledge, such that the effects of participating in the design of a pedagogical

agent's (RQ3a) appearance, (RQ3b) personality, and (RQ3c) feedback style on declarative knowledge are particularly pronounced for those with a relatively high desire for control? [5]

Method

Design

This experiment employed a 2 X 4 fully crossed design. The first independent variable, participation status, had two levels: participation and no participation (i.e., the control group) which represented those who did and did not participate in the design of their pedagogical agent respectively. The second independent variable, participation type, had four levels: appearance participation (AP), personality participation (PP), feedback style participation (FP), and multiple participation (MP; appearance, personality, and feedback style). Participants in the AP and MP choice conditions were given the option to select the gender and ethnicity (Caucasian, African American, Hispanic, or Asian) of their agent. Those in the PP and MP choice conditions were allowed to determine whether the agent would (a) make jokes vs. be serious, and (b) be empathetic vs. unemotional. Finally, participants in the FP and MP conditions were asked to decide whether the agent would (a) tell them how they were performing compared to others (normative feedback) vs. compared to their own past performance (self-referenced feedback) and (b) tell them what to do (directive feedback) vs. simply offer suggestions and let them decide (nondirective feedback).

A yoked control group design was used; that is, four "no participation" control groups were created to correspond to the four (AP, PP, FP, and MP) experimental groups. Each

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[5] Because a directional hypothesis was not predicted for the effects of participation on declarative knowledge, possible moderation effects are also explored in the form of a research question, rather than a hypothesis.

participant in a given control group was assigned an agent using the characteristics chosen by a member of the corresponding experimental group, creating yoked dyads. The first member of each dyad was randomly assigned to one of the four participation groups, and their counterpart was assigned based on the order of signup. This yielded a total of eight experimental conditions.

The yoked control group design was chosen in order to control for the effects of the agent's characteristics/quality on reactions and learning. In other words, it was important to remove possible confounds from the effects of particular choices made on the quality of the training. For example, if most experimental participants chose "funny" agents and an unanticipated effect of "funny" agents existed, it would be important to ensure that members of the participation and no participation groups were equally likely to interact with a funny agent.

In the AP, PP, and FP conditions, there was a need for the experimenters to determine the values of the nonparticipation categories. For example, although experimental participants in the AP condition chose the agents appearance, the experimenter needed to determine the agent's personality and feedback style. The nonparticipation categories were fixed at set values as follows. First, a list of all possible combinations of nonparticipation characteristics was generated for each of the three conditions. Then, a combination/sequence was randomly chosen, without replacement, for each participating dyad within a condition. This process repeated itself (i.e., the list of all possible combinations was reintroduced) once all possible combinations had been implemented within a condition. Sampling without

replacement was conducted to prevent oversampling of any one combination of characteristics.

Participants

A total of 164 people participated in this study (see Table 1 for a breakdown of participants per condition; 33 people without a matched pair were dropped from the analysis). Participants were undergraduates at a large Southeastern university who volunteered in order to receive course credit ($N = 118$) and members of local organizations ($N = 46$) who responded to an email advertisement (i.e., emails were sent via organization listservs, seeking volunteers who wished to improve their Excel skills). Power analyses revealed that this sample size was sufficient to ensure power of .9 to detect a medium effect at the .05 significance level for a 2 x 4 within-and-between design. Females comprised 59% of the sample. The mean age was 23.8 (SD = 9.79). With regard to ethnicity, 69% were Caucasian, 10% were African American, 4% were Asian, 9% were Hispanic, and 8% reported another ethnicity or multiple ethnicities. Approximately 23% of the sample reported full-time employment, 34% reported part-time employment, and 42% reported no current employment.

Procedure

All training and data collection took place online. Upon signup, participants completed an informed consent form and were directed to a preliminary questionnaire. Participants were then given a random identifier, and assigned to a condition. They were then directed to the training web page. The web page introduced the pedagogical agent by stating, "You will be completing your training today with a computerized tutor, an intelligent agent

that has been designed to help you with this training. Your tutor's name is PJ. PJ will communicate with you by using this chat window."

Participants in the experimental conditions then viewed a web site that asked them to make a series of selections regarding the appearance, personality, or feedback style of their agent, or all of the above characteristics. Participants in the control conditions were given a preliminary statement to read that described their pedagogical agent with regard to appearance, personality, or behavior, but were not given the chance to provide input on these characteristics.

After the participants made their selections or read the descriptions, they began the training. After the training, participants were directed to a set of questionnaires assessing their post-training reactions, learning, and manipulation checks.

Training Program and Pedagogical Agent

All participants worked on a one-hour Microsoft Excel 2007 training activity, with four modules selected to be moderately difficult (e.g., Pivot Tables, Formulas). The training was adapted from Microsoft's Office Online Excel 2007 training courses (Microsoft, 2008). For each module, participants first viewed a series of web pages with text and graphic content (i.e., Excel screen shots and text explanations). Next, they were given a practice test consisting of a set of 6-8 review questions to answer. Based on their performance, the agent either advised them to go back and review the content, or advance to the next module.

The pedagogical agent[6] avatars were created using the Haptek PeoplePutty system (Haptek, 2003). The agent followed a script, automatically generated according to menu options selected prior to the training task. For example, participants selecting an empathetic agent saw messages stating, "You must be proud to get such a high score!" if they performed well on the review sections, while nonempathetic agents stated, "Your score demonstrates mastery." Humorous agents cautioned the participant to pay attention by saying, "Hey! No dozing off now!" while serious agents stated, "Please continue to pay attention." Directive agents advised participants to review earlier material by stating, "You should go back and re-read the material for this section," while nondirective agents stated, "If you want to go back and re-read the material, you may." Finally, agents giving normative feedback stated, "You are performing in the top 50% of learners like you," while agents giving self-referenced feedback stated, "You are improving compared to past modules." The agent made a total of 12 statements during the training, 3 of which corresponded to each of the personality or feedback choices offered. The agent provided each statement in a chat window displayed to the right of the training content (see Figure 2 for the layout of the training web site). The statements were adapted from previous literature when possible, and pilot tested to ensure they conveyed the intended characteristics. Specifically, four raters were asked to read a list of potential statements and select the variable they thought it conveyed. The final list of statements used in the training program included only items that had 100% agreement.

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[6] The program used in this study did not strictly fit the definition of an intelligent agent, in that it did not adapt to the user over time, and was not interactive. However, participants in the study were told that the agent was intelligent.

Measures

All survey items used a 5-point Likert scale with anchors *strongly disagree-strongly agree* unless otherwise noted. For scales comprised of items with differing response scales, items were first re-scaled with a normal transformation (i.e., converted to z scores) before combining the items to create an overall scale score.

Appearance manipulation check (alpha = .89) was measured with two items created for this study, for example "I was able to control the way my agent looked."

Personality manipulation check (alpha = .94) was measured with two items created for this study, for example "I was able to control my agent's personality."

Feedback style manipulation check (alpha = .94) were measured with two items created for this study, for example, "I was able to control the way my agent delivered feedback."

Affective reactions (alpha = .89) were measured with three items taken from Thompson et al. (in press), for example "I am satisfied with the Excel training program," and four additional unpublished items developed by the researchers, for example, "Participating in this web-based training program was a rather negative experience for me" (reverse-scored).

Utility reactions (alpha = .92) were measured with four items created by the researchers, for example, "This web-based training program was a worthwhile learning experience," and the five-item Value/Usefulness subscale adapted from the Intrinsic Motivation Inventory (Ryan, 2008; example item, "I believe this training could be of some

value to me"). These five items were rated on a seven-point Likert scale with anchors *not at all true of me* to *very true of me*.

Engagement (alpha = .92) was measured with two items taken from Brown (2005): "I found that I had been reading and then didn't know what it was all about," and "I often missed important points because I was thinking of other things" as well as the Interest/Enjoyment scale of the Intrinsic Motivation Inventory (seven items): for example, "This activity did not hold my attention at all" (reverse-scored)." These seven items were rated on a seven-point Likert scale with anchors *not at all true of me* to *very true of me*.

Post-training self-efficacy (alpha = .86) was measured with four items adapted from Guthrie and Schwoerer (1994), for example, "I will be able to apply the skills I learned in this training," and six items created to reflect efficacy for specific Excel functions, adapted from Gist, Schwoerer, and Rosen (1989), for example, "I can write a formula to sum a list of numbers." These six items were rated with a 10-point scale with anchors *not at all confident* to *very confident.*

Declarative knowledge was measured with a 20-item multiple choice test taken directly from the Microsoft Online Training program (Microsoft, 2008). The mean item difficulty was .70, and the item difficulty range was .33-.97.

Desire for control was measured with 20 items from Burger and Cooper's (1979) Desire for Control Scale (alpha = .78), for example, "I prefer a job where I have a lot of control over what I do and how I do it." This scale has five subscales: (a) general desire (5 items); (b) decisiveness (5 items); (c) preparation-prevention (4 items); (d) avoidance of dependence (2 items); and (e) leadership (4 items). All items were combined into an overall

DC score, in accordance with previous research in this area (e.g., Sechrist, Swim, & Stangor, 2004; Thompson, Chaiken, & Hazelwood, 1993).

Demographic/background measures included age, gender, ethnicity, class standing, Excel experience, and employment status.

Analysis

Multilevel modeling (MLM; Raudenbush & Bryk, 2002) was used to test the hypotheses in this study. MLM is an extension of ordinary-least-squares (OLS) regression that acknowledges effects on the dependent variable from both the individual level and higher levels. For example, in the current study, training reactions can be expressed as a function of participation status (individual level, level 1) as well as characteristics of the yoked dyad to which a person belongs (group level, level 2). In this study, level 2 effects included both the condition to which a dyad was assigned, as well as particular features of the agent that the dyad interacted with. OLS regression cannot account for level 2 variables. In the current study, this is a concern, given that individuals within yoked dyads were expected to be more similar than individuals across dyads, violating the assumptions of independence of observations and uncorrelated residuals in OLS regression. MLM is an effective way of addressing these violations (Raudenbush & Bryk, 2002).

Hypotheses 1-4 predicted that participation would increase affective reactions, utility reactions, engagement, and self-efficacy, respectively. Research Question 1 explored the possibility of a similar effect with respect to declarative knowledge. Further, it was expected that these effects would differ based on the type of participation offered to participants. To examine this, two sets of models were tested. First, the following equations for a random

coefficients regression model were tested. These models answered the questions, “Did participation status affect the dependent variable (DV)?” “Are there mean differences across dyads in the level of the DV?” and “Did participation have different effects on the DV depending on the dyad a person belongs to?”

$$\begin{aligned} &\text{Level 1:} \quad DV_{ij} = \beta_{0i} + \beta_{1i}(\text{Part. Status}) + r_{ij} \\ &\text{Level 2:} \quad \beta_{0i} = \gamma_{00} + u_{0j} \\ &\qquad\quad \beta_{1i} = \gamma_{10} + u_{1j} \end{aligned} \qquad [1]$$

Where γ_{10} represents the effect of participation status on the DV, and γ_{00} represents the grand mean of the DV. Additionally, the variance of r_{ij} is tested to see if there are within-dyad differences in the DV, the variance of u_{0j} is tested to see if there is variance in the level of the DV across dyads, and the variance of u_{1j} is tested to see if dyads differ with respect to the effect of participation status.

Next, the following models were tested to determine if there was a cross-level interaction between participation type and participation status. That is, did the effect of participation depend on the type and amount of participation offered?

$$\begin{aligned} &\text{Level 1:} \quad DV_{ij} = \beta_{0i} + \beta_{1i}(\text{Part. Status}) + r_{ij} \\ &\text{Level 2:} \quad \beta_{0i} = \gamma_{00} + \gamma_{01}(\text{Part. Type}) + u_{0i} \\ &\qquad\quad \beta_{1i} = \gamma_{10} + \gamma_{11}(\text{Part.Type}) + u_{1i} \end{aligned} \qquad [2]$$

Where γ_{01} represents the effect of participation type on the DV, and γ_{11} represents the effects of different participation types (dummy-coded) on the relationship between participation status and the DV.

Hypotheses 5-8 predicted an interaction between participation and desire for control (DC) on reactions and self-efficacy, and Research Question 3 explored the possibility of a

similar interaction with respect to declarative knowledge. In order to examine each hypothesis/question, the following models were tested. These models included the addition of DC and the interaction between DC and participation status as predictors at level 1. At level 2, no new predictors were added. This model answered the questions, "Did desire for control moderate the effects of participation on each DV?" "Did the nature of the interaction change based on the dyad a person belongs to?" and "Did the nature of the interaction change depending on the type of participation (AP, PP, FP, MP) allowed?"

$$\begin{aligned} &\text{Level 1:} \quad DV_{ij} = \beta_{0i} + \beta_{1i}(\text{Part. Status}) + \beta_{2i}(DC) + \beta_{3i}(DC*\text{Part. Status}) + r_{ij} \qquad [3] \\ &\text{Level 2:} \quad \beta_{0i} = \gamma_{00} + \gamma_{01}(\text{Part. Type}) + u_{0i} \\ &\qquad\quad \beta_{1i} = \gamma_{10} + \gamma_{11}(\text{Part. Type}) + u_{1i} \\ &\qquad\quad \beta_{2i} = \gamma_{20} + \gamma_{21}(\text{Part. Type}) + u_{2i} \\ &\qquad\quad \beta_{3i} = \gamma_{30} + \gamma_{31}(\text{Part. Type}) + u_{3i} \end{aligned}$$

Where γ_{30} represents the effect of the interaction of DC and participation status on the DV, and γ_{31} represents the effect of different types of participation on the interaction between DC and participation status.

Results

Preliminary Analyses

Table 1 contains variable means and standard deviations per condition. Group means showed an interesting pattern. In the appearance and multiple participation groups, all mean differences were in the expected direction, and in the personality group, mean differences appeared negligible. In the feedback group, however, all mean differences appeared to be in the opposite direction from what was expected.

Manipulation checks revealed that the manipulations were successful, as shown in Table 2. For all participation types, paired sample *t*-tests showed significant mean differences on manipulation check variables (described above) between participants who were offered a choice and those who were not.

Descriptive statistics and intercorrelations for all variables are presented in Table 3. Tests of skewness and kurtosis revealed that no significant deviations from normality were present in the dependent variables.

Tests of Hypotheses and Research Questions

The results of the first set of multilevel regression analyses are presented under Model 1 in Tables 4-8. Nonsignificant coefficients for each of the dependent variables indicated that overall, participation did not lead to an increase in affective reactions, utility reactions, engagement, post-training self-efficacy, or declarative knowledge.

Results of the second set of analyses showed that no interaction was present for affective reactions or engagement. Thus, Hypotheses 1 and 3 were not supported. However, both utility reactions and post-training self-efficacy showed an interesting pattern. As seen in Model 2 of Table 7 and Table 8, both dependent variables showed a significant interaction between participation status and type. Decomposition of these effects showed that in the appearance, personality, and multiple conditions, participation slightly increased utility reactions and self-efficacy, although these effects were not significant (see Table 1 for means per condition). But in the feedback condition, participation significantly decreased utility reactions and self-efficacy. This pattern was in the opposite direction predicted by Hypotheses 2 and 4, indicating that these hypotheses were not supported.

Research Question 1 and 2 explored this interactive effect with regard to declarative knowledge. Participation status and type interacted to predict declarative knowledge, as seen in Model 2 of Table 8. Specifically, offering appearance or personality participation had no effect on declarative knowledge, while offering multiple participation opportunities significantly increased declarative knowledge and offering feedback participation significantly decreased it (See Table 1 for means).

Hypotheses 5-8 predicted that the effects of participation would be moderated by desire for control. The third set of multilevel analyses showed that the interaction between participation and DC was not significant for any of the five dependent variables, as shown in Model 3 of Tables 4-8. The three-way interaction between type, status, and DC was also explored, showing similar results. Thus, Hypotheses 5-8 were not supported. In response to Research Question 3, DC did not moderate the effects of participation status on declarative knowledge.

Discussion

Summary of Results

The hypotheses in this study predicted that participation in agent design would improve training reactions and learning. Results of multilevel regression analyses were mixed; they showed that the effects of participation depend on the type and amount of participation offered. Providing appearance, personality, and multiple participation opportunities appeared to slightly increase reactions and post-training self-efficacy; however, mean differences were not significant. Contrary to expectations, feedback participation significantly decreased utility reactions, self-efficacy, and declarative knowledge.

Meanwhile, multiple participation opportunities significantly increased declarative knowledge. Participation did not have any significant effects on affective reactions or engagement. None of the effects on self-efficacy, knowledge, or utility reactions were moderated by desire for control.

Theoretical Implications

As a whole, these findings were somewhat contrary to theoretical predictions. Cognitive dissonance theory predicts that chosen items will be more liked than unchosen items; yet, no effects on liking (i.e., affective reactions) were found in this study. The interference principle predicts that too much participation may distract or overwhelm learners, or cause them to divert attention away from the material and towards the choices they are making with respect to agent design. However, the findings of this study show exactly the opposite: learners offered a relatively greater number of choices performed better, not worse, on a test of knowledge, than learners offered only a subset of those choices. The reason for this pattern is not clear. Brown (2005) argued that a greater amount of engagement should lead to more learning, meaning that if agent design choices led to higher engagement, higher learning would also be expected. However, no significant effects on reactions and engagement were found in this study. So, another mechanism must be at work. One possibility is that multiple agent design choices do not create a strong enough distraction to trigger an interference effect. If this is the case, the number of options offered to the multiple participation group may have been the minimum required to elicit any benefits. Future research in this area will be needed to determine the effects of varying levels of participation.

This finding also has implications for the learner control literature. In general, learner control has been found to increase reactions, while having a smaller impact on learning outcomes (Kraiger & Jerden, 2007). However, Sitzmann et al. (2006) found that among web-based training courses that offered some degree of learner control, those that offered relatively more learner control had a stronger effect on knowledge outcomes. This is consistent with the findings from the current study, in that giving learners multiple choices regarding the appearance, feedback, and personality of their agent improved learning while choice regarding only some of these features did not. Previous research has only examined learner control with respect to pace, sequence, and content of the training material. This study expands our understanding of exactly which aspects of learner control have an impact on learning outcomes during web-based training.

An interesting finding from this study was that the effects of participation with regard to feedback style (directive vs. nondirective, and normative vs. nonnormative) had significantly negative effects on self-efficacy, utility reactions, and knowledge, while other types of participation trended toward positive (although not significant) effects. The reason for this pattern in unclear; it may be that learners' expectations were raised when given the opportunity to select the agent's feedback style, and then disappointment followed when the feedback was not what they expected. Further research in this area will be needed to determine whether this effect was due to the particular agent used in this study, or if it is representative of a larger pattern. It is worth noting that the outcomes that were negatively affected did not include how likable and interesting the training was, but rather how effective and beneficial it was. It is possible that the participants who made choices about feedback

were more apt to second-guess themselves as to whether they had made the most effective choices to assist in their learning. Put another way, feedback about performance may be viewed by participants as more crucial to the training than more superficial aspects of agent appearance and personality.

Implications for Practice

A recent survey of 700 employers found that most managers believed e-learning courses would comprise up to 50% of all training delivered by their organizations within 5 years. However, although 60% of managers at these organizations had access to e-learning courses at the time of the survey, only 30% had taken an e-learning course, and only 30% had completed one (CIPD, 2008). This finding suggests that many managers and employees who have access to e-learning are failing to take full advantage of it. Unlike classroom training, workers are often asked to complete e-learning "on their own time." This can lead to a high rate of forgotten or abandoned courses, which translates into a large expense for the organization. Keeping learners engaged and motivated in e-learning, then, is a critical priority if the proportion of training delivered online continues to grow. It will be essential to continue to explore whether participation in some aspect of agent design can be effective in accomplishing these goals. Although the current study was not successful in identifying factors that increase engagement, it lays important groundwork for future studies in this area.

Limitations

This study had several limitations that must be acknowledged. First, the generalizability of the volunteer sample is unknown. It may be that volunteers have different motivations than trainees participating in required workplace training courses. However, the

subject matter of this training course was typical of workplace trainings, many of the participants volunteered specifically to improve their workplace Excel skills, and the students in this sample could be expected to participate in similar trainings upon entering the workforce. Thus, these results may be representative of a voluntary workplace training context.

Second, the agent used in this course was not completely interactive. That is, the communication between the agent and participant was one-way, and the participant did not have the ability to provide feedback to the agent about the utility of various suggestions. A truly intelligent agent is characterized by interactivity and the ability to learn a user's preferences over time (Bonett, 2001). However, this design was necessary in the current study in order to ensure standardization of the material presented to each participant.

Third, few significant results were found in this study, which may be indicative of insufficient power. Although power analyses showed that the current sample size was sufficient to detect a medium effect, smaller effect sizes would require additional participants. In future studies, a small effect size may need to be anticipated and additional data collected accordingly.

Fourth, it is important to note that although agent design control was the aspect of learner control being manipulated in this study, other aspects of learner control were present for members of all conditions. For instance, participants who were not able to participate in agent design were still able to control the pace and sequence of the material. This means that learners in all conditions were able to benefit from some aspect of leaner control, possibly weakening the effects of agent design control.

Finally, it is worth noting that the avatars in this study may have been subject to what has been termed the "uncanny valley" effect (Mori, 1982). This phenomenon, which has been observed in the human-computer interaction literature (e.g., Oyedele, Hong, & Minor, 2007), describes the reaction of uneasiness experienced when interacting with robots that closely approximate humans. People often find these extremely realistic robots unnerving, as opposed to appealing. Some open-ended comments from participants in the current study suggest that this may have limited the appeal of the agent, masking any potential effects on affective reactions. For example, one participant wrote that the agent was "very unattractive," while another commented:

> *"In reference to PJ in particular, something about the computerized version of a person turned me off a bit...I think if the agent had been something non-human (e.g., an animal, or inanimate object, like the Cat or Dog Microsoft Office Assistant in previous MS Office versions) or even a less realistic human (like the Professor office assistant) I might have paid it more attention. The cyber-person was a little creepy."*

Future Research

Perhaps the most important discovery resulting from this study is that all choice is not created equal. The effects of agent design control during web-based training vary, depending on how much control is permitted and which aspects of the agent the learner is allowed to design. Building on the findings from this study, it will be important to develop a fuller understanding of the precise aspects of agent design control that lead to positive training outcomes. Choices regarding characteristics not included in the current study, such as voice or animation, may have differential effects for learners. In particular, agents who communicate with a human voice have been shown to increase engagement when compared to text communication; however, these effects do not appear to translate to greater learning

gains (Berry et al., 2005). Thus, offering learners a choice with regard to voice may prove to be beneficial for some but not all training outcomes. In fact, several comments from participants indicated that they expected to hear the agent speaking during the training. One noted,

"...I paid little attention to the agent. It may have been more effective for me if there was a aural clue that the agent was trying to interact. The training itself was well written. However, I was surprised that there was no audio with the training."

Other training outcomes may be also affected by agent design control. For example, self determination theory predicts that offering choices serves to increase intrinsic motivation. Future studies may include training motivation among the training criteria of interest. Additionally, it will be essential to understand how effects on training outcomes translate to organizational outcomes. High dropout and incompletion rates are a serious problem in web-based training (Welsh, Wanberg, Brown, & Simmering, 2003). Longitudinal research will be needed in this area to fully understand the way personalized agents affect trainees over time.

Conclusion

The role of choice in training programs is essential: several participants in the no-choice control condition suggested that they would have liked to have more control over the agent's personality and the way it delivered feedback. As one participant noted, "it seemed too directive and too serious. Also, being compared to one's peers versus one's self can seem like criticism in certain aspects." Of course, many learners chose to work with a serious, directive agent, making it clear that there is not one type of agent feedback that is preferred

by everybody. Allowing learners to design an agent that suits their preferences is a way to meet these different needs. Current technology makes this customization possible. Additional research is needed to fully understand its effects.

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Table 1
Item Descriptive Statistics by Condition

	Appearance				Personality				Feedback				Multiple			
	None ($N = 24$)		Choice ($N = 24$)		None ($N = 22$)		Choice ($N = 22$)		None ($N = 18$)		Choice ($N = 18$)		None ($N = 18$)		Choice ($N = 18$)	
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Affective Reactions	2.98	0.79	3.34	0.62	3.27	0.60	3.27	0.77	3.16	0.70	2.84	0.58	3.36	0.83	3.57	0.59
Utility Reactions†	-0.15	0.74	0.28	0.65	0.00	0.73	0.05	0.89	0.19	0.45	-0.36	0.85	-0.08	1.09	0.08	0.75
Engagement†	-0.25	0.74	0.20	0.79	0.08	0.74	0.02	0.93	0.01	0.71	-0.36	0.71	0.06	0.84	0.13	0.75
Self-Efficacy†	-0.26	0.82	0.16	0.63	0.02	0.73	0.20	0.71	0.03	0.46	-0.47	0.86	-0.03	0.52	0.35	0.64
Declarative Knowledge	13.88	3.44	14.33	3.41	14.64	3.11	14.95	2.52	13.11	4.13	11.78	3.81	13.61	4.07	15.61	2.30

†Note: Item means for these variables are presented as *z*-scores, as the items comprising these scales had differing response scales.

Table 2
Manipulation Checks

		Participation Type											
		Appearance			Personality			Feedback			Multiple		
		No Choice	Choice	*t* (*df* = 22)	No Choice	Choice	*t* (*df* = 20)	No Choice	Choice	*t* (*df* = 17)	No Choice	Choice	*t* (*df* = 17)
Perceived Appearance Choice	*M*	2.77	3.72	2.80**							2.64	3.61	2.72*
	SD	1.51	0.84								1.15	0.99	
Perceived Personality Choice	*M*				2.26	4.07	4.76**				2.81	3.69	2.56*
	SD				1.10	0.89					1.39	1.00	
Perceived Feedback Choice	*M*							2.92	3.58	2.54*	2.78	3.83	2.70*
	SD							0.86	0.97		1.41	1.00	

Note: * $p < .05$, ** $p < .01$.

Table 3
Variable means, standard deviations, and intercorrelations

	M	SD	1	2	3	4	5	6	7	8	9
1. App. Manip. Check	2.80	1.18									
2. Pers. Manip. Check	2.66	1.24	.31**								
3. Feed. Manip. Check	2.76	1.19	.30**	.72**							
4. Desire for Control	3.58	0.39	.07	-.08	-.06						
5. Training Time	41.98	52.19	-.11	-.11	-.15	.18*					
6. Declarative Knowledge	14.04	3.48	.13	.04	-.02	.07	.06				
7. Affective Reactions	3.22	0.71	.16	.19*	.12	.15	-.02	.10			
8. Utility Reactions†	0.01	0.79	.03	.07	.01	.10	-.07	-.01	.71**		
9. Engagement†	-0.01	0.79	.15	.20*	.12	.10	-.11	-.01	.76**	.68**	
10. Post-Training Self-Efficacy†	0.00	0.71	.06	.15	.06	-.01	-.07	.36**	.46**	.47**	.40**

Note: $N = 164$. * correlation is significant at $p < .05$; ** $p < .01$. †Means for these variables are presented as z-scores.

Table 4
Effect of Participation, Desire for Control, and Participation Type on Affective Reactions

	Model 1		Model 2		Model 3	
	Coeff.	*SE*	Coeff.	*SE*	Coeff.	*SE*
Fixed Effects						
Intercept, γ_{00}	3.18**	0.08	3.36**	0.16	2.26	0.78
Participation, β_1						
Intercept, γ_{10}	0.09	0.10	0.21	0.22	1.37	1.91
Participation*Appearance[7] , γ_{11}			0.14	0.29	-1.23	2.29
Participation*Personality , γ_{12}			-0.21	0.29	-1.84	2.32
Participation*Feedback , γ_{13}			-0.52	0.31	-2.31	2.28
Desire for Control, β_2						
Intercept, γ_{20}					0.31	0.21
Participation*DC, β_3						
Intercept, γ_{30}					-0.31	0.52
Partic*Appearance*DC, γ_{31}					0.36	0.62
Partic*Personality*DC, γ_{31}					0.43	0.64
Partic*Feedback*DC, γ_{31}					0.46	0.62
Random Effects						
Within Dyads, σ^2	0.42**	0.07	0.41**	0.07	0.41**	0.07
Between Dyads, τ_{00}	0.08	0.06	0.06	0.06	0.06	0.06

[7] Participation type was dummy-coded such that the Multiple Participation condition was the reference group. The overall effect of the participation*type interaction was not significant, $F(3, 75.9) = 1.94$, $p = .13$.

Note: $N = 140$. *$p < .05$, **$p < .01$.

Table 5
Effect of Participation, Desire for Control, and Participation Type on Utility Reactions

	Model 1		Model 2		Model 3	
	Coeff.	*SE*	Coeff.	*SE*	Coeff.	*SE*
Fixed Effects						
Intercept, γ_{00}	-0.02	0.09	-0.09	0.19	-0.83	0.95
Participation, β_1						
Intercept, γ_{10}	0.06	0.12	0.17	0.26	1.87	2.25
Participation*Appearance[8] , γ_{11}			0.26	0.34	-1.64	2.68
Participation*Personality , γ_{12}			-0.12	0.34	-2.35	2.69
Participation*Feedback , γ_{13}			-0.71*	0.37	-2.88	2.67
Desire for Control, β_2						
Intercept, γ_{20}					0.21	0.26
Participation*DC, β_3						
Intercept, γ_{30}					-0.46	0.62
Partic*Appearance*DC, γ_{31}					0.53	0.73
Partic*Personality*DC, γ_{31}					0.61	0.75
Partic*Feedback*DC, γ_{31}					0.61	0.72
Random Effects						
Within Dyads, σ^2	0.61**	0.10	0.58**	0.09	0.60**	0.11
Between Dyads, τ_{00}	0.01	0.07	0.03	0.07	0.04	0.08

[8] Participation type was dummy-coded such that the Multiple Participation condition was the reference group. The overall effect of the participation*type interaction was significant, $F(3, 77.6) = 2.71$, $p = .05$.

Note: $N = 140$. *$p < .05$, **$p < .01$.

Table 6
Effect of Participation, Desire for Control, and Participation Type on Engagement

	Model 1		Model 2		Model 3	
	Coeff.	*SE*	Coeff.	*SE*	Coeff.	*SE*
Fixed Effects						
Intercept, γ_{00}	-0.03	0.09	0.06	0.18	-1.05	0.93
Participation, β_1						
Intercept, γ_{10}	0.05	0.12	0.06	0.25	1.16	2.18
Participation*Appearance[9] , γ_{11}			0.38	0.33	-1.88	2.60
Participation*Personality , γ_{12}			-0.13	0.33	0.82	2.61
Participation*Feedback , γ_{13}			-0.44	0.36	-0.85	2.58
Desire for Control, β_2						
Intercept, γ_{20}					0.33	0.25
Participation*DC, β_3					-0.30	0.60
Intercept, γ_{30}						
Partic*Appearance*DC, γ_{31}					0.62	0.70
Partic*Personality*DC, γ_{31}					-0.28	0.72
Partic*Feedback*DC, γ_{31}					0.14	0.70
Random Effects						
Within Dyads, σ^2	0.57**	0.07	0.54**	0.09	0.53**	0.09
Between Dyads, τ_{00}	0.05	0.09	0.07	0.07	0.07	0.07

[9] Participation type was dummy-coded such that the Multiple Participation condition was the reference group. The overall effect of the participation*type interaction was marginally significant, $F(3, 76.9) = 2.06$, $p = .11$.

Note: $N = 140$. *$p < .05$, **$p < .01$.

Table 7
Effect of Participation, Desire for Control, and Participation Type on Self Efficacy

	Model 1		Model 2		Model 3	
	Coeff.	*SE*	Coeff.	*SE*	Coeff.	*SE*
Fixed Effects						
Intercept, γ_{00}	-0.07	0.08	-0.03	0.16	0.53	0.77
Participation, β_1						
Intercept, γ_{10}	0.14	0.10	0.37	0.21	-0.40	1.89
Participation*Appearance[10] , γ_{11}			0.06	0.27	-0.38	2.26
Participation*Personality , γ_{12}			-0.19	0.28	-1.45	2.27
Participation*Feedback , γ_{13}			-0.86**	0.29	-1.91	2.23
Desire for Control, β_2						
Intercept, γ_{20}					-0.16	0.21
Participation*DC, β_3						
Intercept, γ_{30}					0.25	0.52
Partic*Appearance*DC, γ_{31}					0.10	0.62
Partic*Personality*DC, γ_{31}					0.29	0.63
Partic*Feedback*DC, γ_{31}					0.25	0.61
Random Effects						
Within Dyads, σ^2	0.42**	0.07	0.38**	0.06	0.37**	0.07
Between Dyads, τ_{00}	0.09	0.06	0.10	0.06	0.09	0.06

[10] Participation type was dummy-coded such that the Multiple Participation condition was the reference group. The overall effect of the participation*type interaction was significant, F(3,77)=4.48, p<.01.

Note: $N = 140$. *$p < .05$, **$p < .01$.

Table 8
Effect of Participation, Desire for Control, and Participation Type on Knowledge

	Model 1		Model 2		Model 3	
	Coeff.	*SE*	Coeff.	*SE*	Coeff.	*SE*
Fixed Effects						
Intercept, γ_{00}	13.85**	0.38	13.61	0.80	15.59	3.80
Participation, β_1						
Intercept, γ_{10}	0.37	0.52	2.00*	1.10	-1.57	9.33
Participation*Appearance[11] , γ_{11}			-1.54	1.46	-0.23	1.10
Participation*Personality , γ_{12}			-1.68	1.48	1.09	1.12
Participation*Feedback , γ_{13}			-3.33*	1.56	-0.03	1.20
Desire for Control, β_2						
Intercept, γ_{20}					-0.50	1.04
Participation*DC, β_3						
Intercept, γ_{30}					0.94	2.55
Partic*Appearance*DC, γ_{31}					2.32	3.03
Partic*Personality*DC, γ_{31}					1.66	3.12
Partic*Feedback*DC, γ_{31}					2.20	2.99
Random Effects						
Within Dyads, σ^2	11.05**	1.73	10.90**	1.75	11.40**	2.00
Between Dyads, τ_{00}	1.04	1.35	0.54	1.30	-0.26	1.42

[11] Participation type was dummy-coded such that the Multiple Participation condition was the reference group. The overall effect of the participation*type interaction was not significant, $F(3, 78) = 1.53$, $p = .21$.

Note: $N = 140$. *$p < .05$, **$p < .01$.

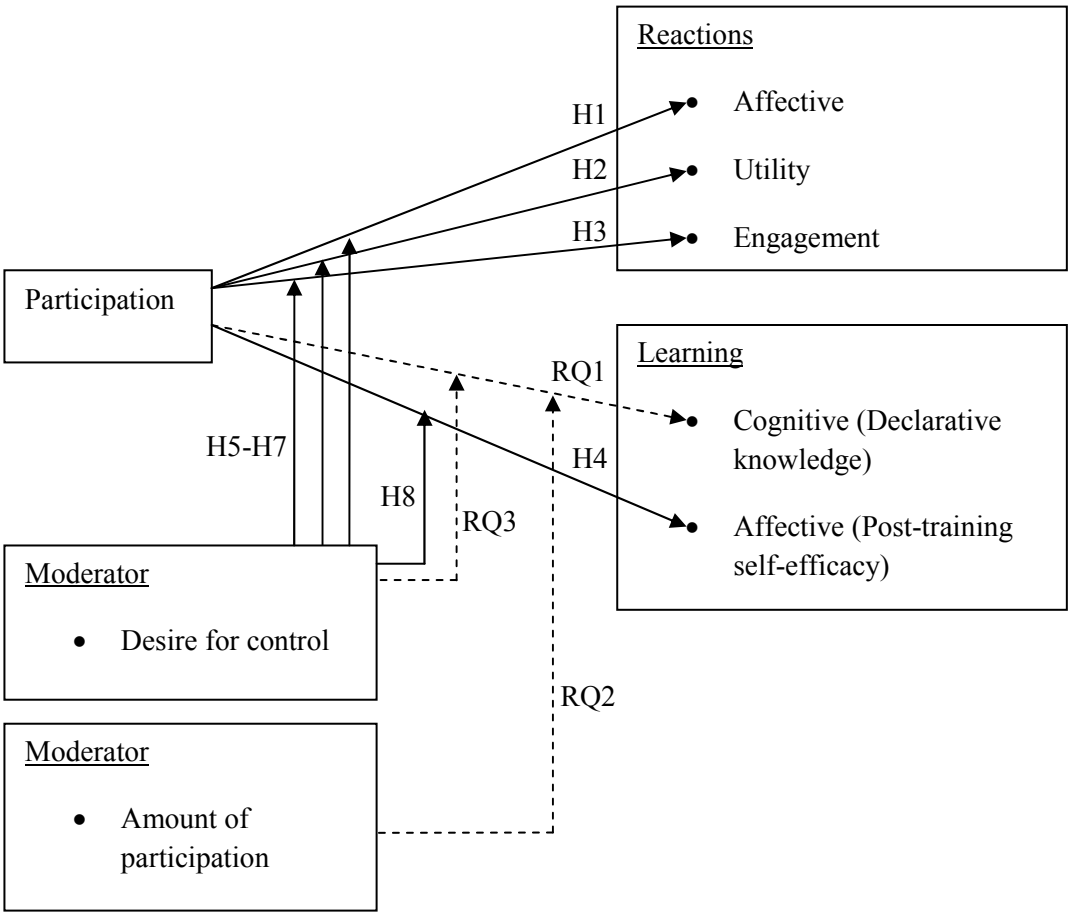

Figure 1. Proposed Model of Effects of Participation in Pedagogical Design on Training Outcomes

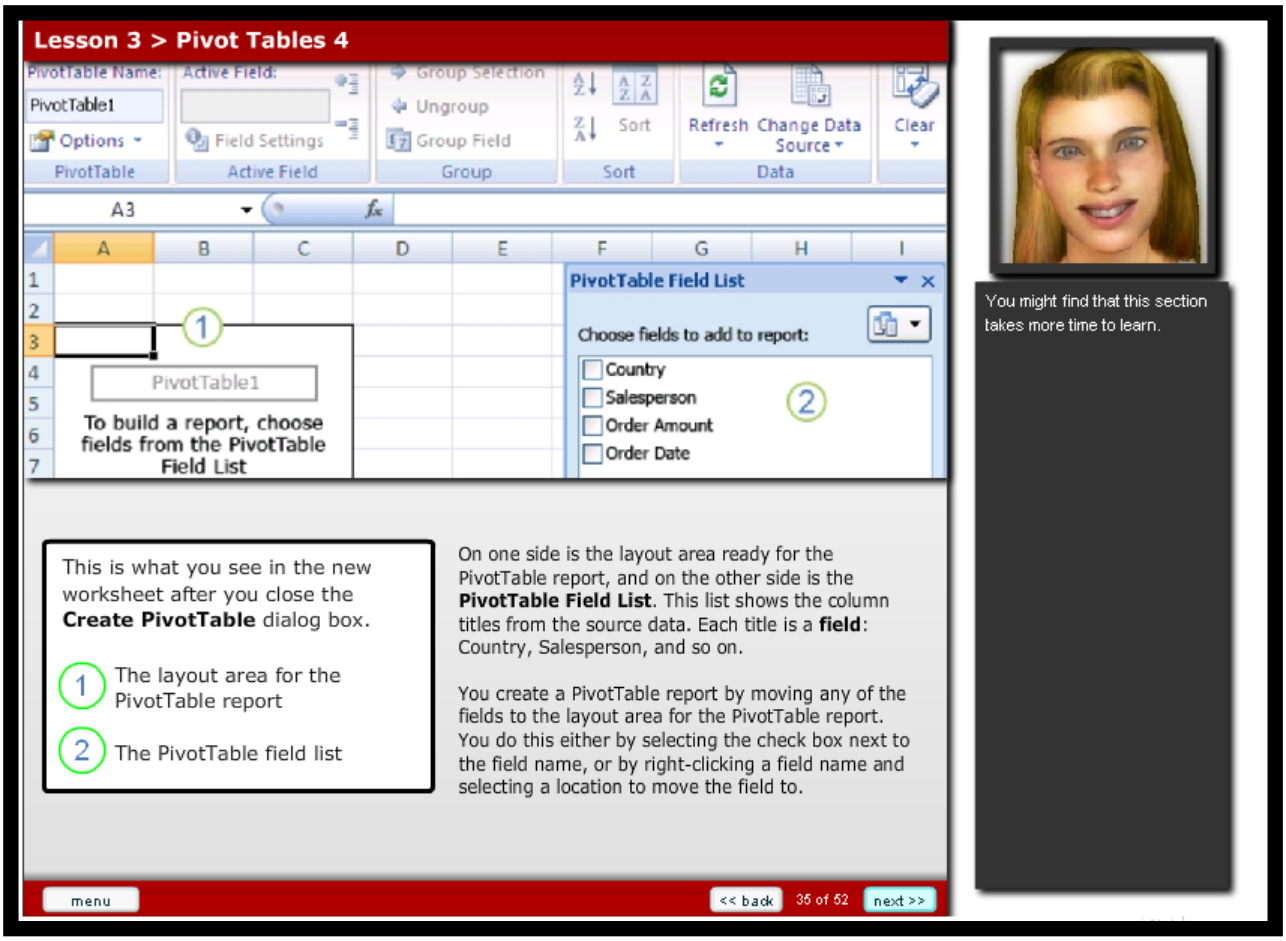

Figure 2. Training Module Layout

APPENDIX

Appendix A.

Proposal Document

PARTICIPATION IN PEDAGOGICAL AGENT DESIGN: EFFECTS ON TRAINING OUTCOMES

Today's increasingly virtual world of work prompts a critical need for research designed to maximize the usefulness of web-based training, which has become a common method for teaching employees the knowledge and skills needed to do their jobs. Intelligent agents (i.e., pedagogical agents) are a potentially viable mechanism for engaging and motivating trainees; however, there is still much to be learned about the factors that shape the effectiveness of intelligent agents during training. The purpose of this study is to examine whether giving e-learners the opportunity to customize and participate in the design of a pedagogical agent influences important training outcomes. The following pages provide an overview of relevant empirical and theoretical work underlying the hypotheses proposed in this study.

Virtual Training

Technological advances are rapidly changing the way that organizations train their employees, and virtual training is now pervasive. Commonly referred to as the "e-learning revolution" (Galagan, 2000; Welsh, Wanberg, Brown, & Simmering, 2003), web-based or computer-based training is gaining in popularity as organizations attempt to capitalize on the many possibilities this medium offers. Sitzmann et al. (2006) reported that 27% of companies

offered technology-delivered training as of 2004, with an expected increase. Further, 1100 institutions of higher education offered online courses in 2006.

Relative to more conventional alternatives such as classroom training, e-learning has a number of advantages. For example, e-learning can provide beneficial features that are not easily replicable in traditional classroom settings, such as immediate individualized feedback (Kulik & Kulik, 1988; Phye & Andre, 1989). Technology also permits the instructional designer to incorporate more customization of the material, and cross-reference other relevant material in real-time. From the trainer's perspective, e-learning enables the delivery of an accurate and updated curriculum to dispersed employees, as well as more frequent updates of the material as policies or information change.

Learner control is also considered an appealing aspect of e-learning. Many online training programs allow the learner to customize the pace and schedule of the material, making it possible to leave and return to the training as situational factors demand. Learners may also be able to control the sequence of material that is provided, the number of topics covered, and the total amount of material covered (DeRouin, Fritsche, & Salas, 2005; Sims & Hedberg, 1995). Learner control is often seen as a major advantage of e-learning, and has been found improve engagement and other learning outcomes (Kraiger & Jerden, 2007).

Although these benefits are significant, e-learning has drawbacks as well. Greater flexibility can lead to problems. Many people are more comfortable with classroom environments, and the isolation of a web-based course can make it less fulfilling and more anxiety-provoking than classroom training. A survey of e-learning providers indicated that lack of interaction was a primary concern for e-learners, and made e-learning less attractive

than classroom training and potentially less useful as well (Welsh et al., 2003). One provider noted that although network technology could make peer-to-peer interaction possible, these tools are very resource-intensive and typically not financially accessible to e-learners (DeRouin et al., 2004).

Another drawback is that certain aspects of learner control which make e-learning attractive, such as greater flexibility and customization, may have negative consequences. Left to their own devices, learners are not always motivated or engaged enough to devote sufficient time and attention to their training. E-learners are required to make many decisions about what to learn and how, and this can result in a high proportion of skipped content or dropout rates. One training provider estimated that 40% of its online courses are never completed (DDI, 2003). This trend is especially concerning, given the findings that trainees who benefit most from training are those who devote the most time and effort to practicing the material (Brown, 2001). As such, suboptimal learner choices (e.g., skipping important material) may decrease learning outcomes (Brown, 2001).

Thus, although learner control is often touted an important advantage of computer-based training (Clark & Mayer, 2008; Kraiger & Jerden, 2007), it can have positive or negative effects, depending on the choices learners make. This suggests a need to better understand learner control in order to effectively incorporate it into training. One particularly fruitful research avenue entails exploring alternative participation mechanisms which allow e-learners to control aspects of their training design which do not influence their degree of exposure to the material. For example, DeRouin et al. (2004) recommended that one way to provide control in e-learning programs is to share *design control*. These authors used screen

size, color, and text size as examples of design control. As technological innovations continue develop, the potential for introducing design control into additional aspects of training programs increases. It is possible that by examining new forms of design control, we can discover ways to keep learners engaged and interested in training while alleviating some of the negative side effects (e.g., suboptimal training content decisions) often associated with computer-based training and learner control.

As discussed next, intelligent agents are one innovation that have potential to increase engagement and reduce isolation by acting as a colearner. At the same time, providing for learner control over the design of the agent may prompt some of the positive effects of learner control while minimizing the negative effects. Drawing from psychological theory regarding the effects of providing personal choice to learners, the following pages explore the potential benefits of incorporating this new form of learner control into computer-based training.

Intelligent Agents

Intelligent agents are used in a wide variety of educational, organizational, and commercial settings. An intelligent agent is a software application that gathers information from users and then delivers customized content and/or services (Bonett, 2001). Agents can learn in real time and adapt to users' preferences and external information. For instance, the web site Amazon.com employs agentic technology when it uses a customer's purchase history to make recommendations, based on what similar customers purchased. The agents allow for continuous feedback; a customer may specify whether a particular recommendation is helpful or not, and the agent will remember the customer's preferences and learn from this

feedback. Animated pedagogical agents (APAs) are a specific class of agents that are represented as a human or animal body within the virtual environment, designed to facilitate learning (Baylor & Kim, 2005). APAs can be used in a variety of learning settings, and can be programmed to fill a number of diverse roles; for example, an APA may act as a tutor, instructor, coach, or peer (Lee et al., 2007). Chou (2003) states that the "positive impact of research on educational agents lies in its ability to strengthen the social learning environment" (p. 260). In this context, agents may serve as buddies, coaches, or colearners, working alongside the learner to provide comfort, reduce isolation, and act as a positive role model. Kim and Baylor (2005) argue that whereas traditional computer-based learning environments often fail to provide situated social interaction, this can now be obtained through APAs. For example, Bickmore et al. (2005) assigned a group of 21 elderly citizens to work with a virtual coach named Laura, who supported them in the ambition to increase their physical activity by walking. Laura's purpose in this study was to provide both encouragement and social support. Agents have been used in this fashion across a wide spectrum of demographic groups and learning contexts (see Gulz, 2005 for a review).

Agents have also been framed as "colearners," or peers. In this context, agents appear to learn the material along with the student, serving as a source of social support and sometimes modeling the correct behavior. For example, Lee et al. (2007) designed a pedagogical colearner that appeared to learn English idioms along with a human learner (middle school student). This colearner agent was designed to demonstrate emotion as it learned; for example, when it answered an item incorrectly, it expressed sadness or

frustration. Similarly, when the e-learner answered an item correctly, the agent provided encouragement and congratulations.

Researchers in the educational domain have begun to study the effects of these agents on learners. From these studies, it is clear that the presence of an agent can sometimes improve learner engagement and motivation, although these effects may depend on the features of the agent itself. As described next, researchers have had occasional success in identifying agent characteristics that are beneficial to learners. However, it is important to note that very few studies have given learners explicit choices to make regarding the agent. That is, although researchers have examined the effects of a wide range of agent characteristics, the characteristics are typically fixed for a particular learner. Learners have seldom been given control over the appearance or behavior of the agent.

Effects of Agents on Learners

Previous studies measuring the effect of agents on learners have shown that the mere presence of an agent sometimes increases enjoyment. For example, Atkinson (2002) found that a group of 100 undergraduate students enjoyed a computer-based training session more when information and examples were presented via an animated agent than when reading the same information presented in text only or by voice only. Participants also rated examples from the training program as less difficult when they were presented by an agent compared to other presentation formats. Similarly, Berry, Butler, and DeRosis (2005) compared the effects of an animated agent named GRETA who delivered information about healthful eating to the effects of the same information delivered in plain text or read by a human actor. Results demonstrated that GRETA was rated as more helpful than voice or text only.

However, this effect is not always found; sometimes users report that a non-agent activity is more entertaining and enjoyable than the same activity with an agent (Den & van Mulken, 2000).

The effect of agents on learning is not entirely understood. There is some controversy surrounding the question of whether agents are capable of creating learning gains. Proponents of pedagogical agents claim that the presence of an agent leads to higher engagement, which in turn causes learners to retain more of the material (Lester & Stone, 1997). Other researchers claim that the agent merely distracts the learner from the material, and that simpler instructional design features accomplish the same goals an agent is intended to accomplish (e.g., providing feedback, introducing material, etc; Choi & Clark, 2006). A third position on the matter is more nuanced. According to Kim and Baylor (2005), agents have no universal effect on learning. This assertion is supported by the results of numerous studies that have failed to find significant learning gains or losses when comparing online instruction with and without agents. For example, Choi and Clark (2006) compared an animated agent to an arrow that pointed to relevant information, both accompanied by a voice, and found no differences in 300 middle school students' learning of an English grammar lesson. Choi and Clark (2006) note that "although students may enjoy their interaction with an agent, it does not mean they will learn better" (p.444).

Thus, agents do sometimes have positive effects on training outcomes. However, given the wide range of findings, it is clear that not all agents have equivalent effects on learners. Accordingly, researchers have moved past the simple comparison of agent-based training and non-agent-based training, to explore the specific characteristics of agents that

may contribute to their effectiveness. Some of these characteristics include the agent's appearance (e.g., Baylor & Kim, 2004), expression of empathy (e.g., McQuiggan & Lester, 2007), embodiment (e.g., Lee et al., 2006), animation (e.g., Craig, Gholson, & Driscoll, 2002), personality (Isbister & Nass, 2000), or manner of delivering feedback (e.g., Kim, Baylor, & Shen, 2007). Although an exhaustive review of all agent characteristics is beyond the scope of this study, the following sections contain an overview of some of the more frequently examined agent characteristics, namely appearance, personality, and feedback style.

Frequently Studied Agent Characteristics

Appearance

There is some evidence that learners are more likely to rely on advice from an agent whose ethnicity is similar to their own. Pratt et al. (2007) matched adult learners with either a Caucasian or African-American computer agent, and found that learners changed their opinion to be consistent with agent advice to a greater degree when matched with a same-ethnicity agent. The authors used a social identity framework to explain these findings, suggesting that learners feel more positively about a same-ethnicity agent and thus are more likely to rely on its advice. These findings are also consistent with Lee and Nass (1998), who found that same-ethnicity agents were rated as more attractive and more trustworthy than different-ethnicity agents. Learners were also more likely to adjust their decisions to match the agent's when the agent shared their ethnicity.

Researchers have also studied other aspects of agent appearance. For example, Kim et al. (2007) examined the effect of agent gender. Students in their study worked with an agent

named Chris to learn a lesson as part of a computer literacy course. Students who worked with male Chris showed significantly higher interest in the task and in working with Chris than did students working with female Chris. Further, students who worked with male Chris scored higher on a test of recall. However, the researchers did not include participant gender in their analyses, so it is unclear whether this effect was found for all learners.

Thus, it seems that agent appearance can affect learners, although the nature of the appearance-outcomes relationship may depend on the learner. Some learners may work better with agents that look similar to themselves, or may prefer an agent of a particular gender. Gulz (2005) demonstrated that learners are able to articulate preferences for particular agent characteristics; further, the author argues that flexibility be built into agent design in order to accommodate these learner preferences. In addition to appearance, flexibility can be built into the communicative style and behavior of the agent. The following sections describe several aspects of agent characteristics that can be varied in this way; namely, feedback style and personality.

Feedback Style

Lester, Converse, Stone, Kahler, and Barlow (1997) examined the effects of various feedback types on student performance, comparing five versions of an animated bug named Herman. The "fully expressive" Herman used three types of communicative behaviors: principle-based spoken advice without animation (e.g., "Remember that small leaves are struck by less sunlight"), principle-based advice with animation, and task-specific spoken suggestions (e.g., "Choose a long stem so the leaves can get plenty of sunlight in this dim environment"). Lester et al. compared this fully expressive Herman with three versions that

used only one form of communication (i.e., either principle-based spoken advice without animation, principle-based advice with animation, or task-specific spoken suggestions), and a version that was mute. Middle-school students who interacted with the versions of Herman that were either fully expressive or gave principle-based spoken advice performed better on a problem-solving test than children who interacted with the mute Herman and the version that provided only task-specific suggestions. The fully expressive Herman also received higher ratings than the other versions on helpfulness.

Researchers have also examined other types of feedback behavior. Kim et al. (2006) compared a proactive agent (i.e., an agent that offered advice before being asked to do so) to a responsive agent (i.e., an agent that waited for the user to ask for help). In their study, the agent was framed as a computerized peer who was learning along with the participants (i.e., a learning companion). Students who worked with the proactive learning companion had significantly higher scores on a recall test, but did not do any better on a test of application. Additionally, interaction type had no effect on learner attitudes toward the agent. The reason for this finding may be that certain types of learners preferred different feedback styles; students in this study, as well as Lester et al.'s (1997) study, were assigned to receive a particular type of feedback and were not permitted to choose the feedback type that best suited their preferences.

Wang et al. (2008) provided some evidence that individual differences may explain variation in preferences for a particular type of feedback. Wang et al. tested the hypothesis that polite agents are more effective than impolite (i.e., directive feedback) agents. They found that students who interacted with a polite agent scored higher than those who

interacted with an impolite agent on a multiple-choice knowledge test. Importantly, they found that this effect was particularly strong for more extraverted students and students who were relatively high in need for cognition. Interestingly, no overall differences were found between students who worked with the impolite agent, compared with the polite agent, in student's level of liking for the agent, interest in the task, or desire to work with the agent again. As noted previously, this lack of results could be due to different types of learners preferring different types of feedback.

Personality

Finally, researchers have attempted to identify personality characteristics that may be more or less appealing to users. Nass et al. (1995) matched dominant[12] or submissive users with either dominant or submissive computers. Users preferred to work with computers that matched their own personalities, rated matched computers as more intelligent, and were more likely to listen to the matched computers' than the unmatched computers' suggestions. No main effect of computer "personality" was found; that is, there was not a single computer personality that was preferred overall. Similarly, Nass and Lee (2001) discovered that introverted users found a computerized voice more attractive when it signaled an introverted personality compared to an extraverted personality; further, they were more likely to rate the voice as credible and were more likely to act on its recommendations (i.e., purchase a recommended book). A similar pattern was observed for extraverted users; that is, users more often preferred to listen to a computer voice that matched their own personality.

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[12] Dominance is a facet of the California Personality Inventory that roughly corresponds to the Assertiveness subfacet of extraversion in the NEO-PI.

In sum, although a wide range of outcomes have been examined, no clear consensus has emerged regarding the most effective design characteristics for increasing learning and engagement. One probable reason for this lack of consensus is that the most effective type of agent depends on a user's unique preferences. As mentioned previously, agent characteristics are typically fixed for a given learner, eliminating the possibility of learner control over the interaction. For example, one learner may wish to work with an agent that offers a great deal of feedback, while another may prefer to be "left alone." People may learn best from an agent that shares their personality traits, or one that they feel comfortable with. However, many studies do not provide the opportunity for learners to tailor their agent to create this similarity or comfort level. Because we know that user preferences for different agent characteristics vary, it makes sense to allow users to choose the type of agent they will interact with. Giving a user control over the design of an agent is one way to increase the chances that they will like their agent and feel comfortable with it.

Another important reason to provide learner control over agent design draws from the participation/voice literature. Voice and participation in the design of technology have been found to improve user satisfaction and acceptance (Carayon & Karsh, 2000; Douthitt & Aiello, 2001; Korunka & Vitouch, 1999). Participation also plays an important role in training (Clark & Mayer, 2008). The following sections provide a theoretical background for the benefits of participation, which are central to the hypotheses and research questions proposed in this study.

Effects of Participation: Theoretical Foundation

The ability to exert control over one's environment has been described as a basic human need (Langer, 1975; Kelley, 1971; Mischel, Cantor, & Feldman, 1996). In the work context, control is a broad concept; it includes everything from control over one's work schedule to participative decision-making. Researchers normally agree that control is important for general well-being as well as more specific outcomes such as job satisfaction (Ganster & Fusilier, 1989; Troup & Dewe, 2002). In addition, control has important implications for work stress (e.g., Demand Control Model; Karasek, 1979). The perception of personal control has also been found to positively relate to one's ability to maintain effort at a challenging task over time (Aspinwall & Taylor, 1992). Participation, or choice, is often used as a proxy or synonym for control, but can most accurately be described as a key antecedent to perceptions of control (Skinner, 1996). Participation tends to have positive effects on user acceptance of new technology (Coovert & Thompson, 2003).

There are several reasons why participation in the design of pedagogical agents should have beneficial effects for trainees. As described next, these reasons correspond to the following theoretical frameworks: procedural justice theory (Levanthal, 1980), self determination theory (Deci & Ryan, 1985), cognitive dissonance (Festinger, 1957) and similarity-attraction (Byrne & Nelson, 1965).

Procedural Justice

From a procedural justice perspective, the positive effects of participation can be explained due to their relationship with voice perceptions. *Procedural justice theory* (Levanthal, 1980) states that in organizational settings, procedures are determined to be fair when they meet six criteria: procedures should (a) be applied consistently across people and

across time, (b) be free from bias, (c) ensure that accurate information is collected and used in making decisions, (d) have some mechanism to correct flawed or inaccurate decisions, (e) conform to personal or prevailing standards of ethics or morality, and (f) ensure that the opinions of various groups affected by the decision have been taken into account. Of these, the last criterion is typically referred to as *voice*, and represents the ability for individuals affected by a decision to voice any concerns or opinions they may have regarding the decision.

Past research into the nature of new technology acceptance has supported the idea that voice, participation, or control can lead to positive outcomes. For example, Carayon and Karsh (2000) conducted a quasi-experimental study comparing two organizations; one simply implemented a new technological infrastructure while the other sought employees' input during implementation. Employees who were able to give their input reported being more satisfied with the new technology. Douthitt and Aiello (2001) found that participants in an experiment who were given process control, in the form of input into the design of electronic monitoring systems, viewed the monitoring as more fair and were more satisfied with the task than participants who were not given process control.

Related to fairness perceptions, uncertainty management theory may also help to explain the effects of participation in computer-based training contexts. Uncertainty management theory (Lind & van den Bos, 2002) proposes that when individuals face uncertainty in their environment, fairness concerns become more salient and thus reactions to unfair events become more negative that would otherwise be the case. This increased salience occurs because people feel anxious about their ability to control their immediate

environment, so they seek ways to provide "protection" against uncertainties. Virtual and computer-based environments are said to be a source of uncertainty for workers (Tangirala & Alge, 2006). In a computer-based training context, it is therefore likely that learners will feel uncertain about the training, especially if they have not used computers to learn previously. Thus, according to uncertainty management theory, learners will be especially attuned to possible sources of unfairness. Since voice influences fairness perceptions, it follows that providing a form of participation in the design of a pedagogical agent may lead to positive perceptions among e-learners.

Self Determination Theory

Past research in the domain of e-learning (e.g., Flowerday & Schraw, 2003) has also drawn from self determination theory when examining the effect of participation on learning outcomes and attitudes (SDT; Deci & Ryan, 1985; Ryan & Deci, 2000). SDT is an influential meta-theory of motivation that claims humans are motivated by three basic needs: relatedness, competence, and autonomy. Of these, competence and autonomy are influenced by participation. Competence is defined as "understanding how to attain various external and internal outcomes and being efficacious in performing the requisite actions" (Deci et al., 1991, p. 327). With regard to competence, participation sends the message to learners that they are capable of making decisions regarding their own learning. Autonomy needs are met as people experience the sense that they are free to make their own decisions. It is important to note that autonomy is not synonymous with independence; autonomy is not the absence of external influences on one's behavior. Rather, it is a person's endorsement of the influences (Ryan & Deci, 2006). Giving trainees the opportunity to participate in the design of a

pedagogical agent can raise their autonomy because it increases the likelihood that they will support the resulting outcome or course of events. That is, trainees should be more likely to accept the training and feel it is their decision to complete it if they are allowed to participate in the design of a pedagogical agent.

The fulfillment of these basic competence and autonomy needs are important because of their effects on *intrinsic motivation*. Deci and Ryan (1985) outlined a continuum of motivation, ranging from intrinsic to extrinsic. People who are intrinsically motivated to perform a task fully identify with the task, and perform the task because it is interesting. Meanwhile, people who are extrinsically motivated perform a task for some external reason (e.g., for pay, or because someone in authority directed them to do so). It is not typical that a person's motivation to perform a task be entirely intrinsic or extrinsic; between the two endpoints of the continuum are introjected (i.e., partial assimilation of external controls), identified (i.e., a personal valuing of the actions) and integrated (i.e., both personally valued and well synthesized with the totality of one's values and beliefs) forms of motivation. These motivational states have been shown to lie on a continuum of relative autonomy (Ryan & Connell, 1989). Ryan and Deci (2000) summarize the large body of research showing the effects of intrinsic motivation on a wide range of outcomes, noting, "The advantages of greater internalization …[include] more behavioral effectiveness, greater volitional persistence, enhanced subjective well-being, and better assimilation of the individual within his or her social group." (Ryan & Deci, 2000, p 73.)

The effects of intrinsic motivation have implications for learning. Broadly, the degree to which educators support autonomy predict both engagement and learning outcomes (Ryan

& LaGuardia, 1999). Flowerday and Schraw (2003) conducted a series of experiments examining two different aspects of participation[13], choice of pace and choice of task (either writing an essay or solving a crossword puzzle). Choice of pace and task both had positive effects on affective engagement. The authors attribute these effects to the greater sense of autonomy experienced by students who had a choice, noting, "those students who are free to choose how much effort to invest in learning should process information at a deeper level than students who cannot choose, because of a greater sense of autonomy and intrinsic motivation" (Flowerday & Schraw, 2003, p. 208).

The propositions set forth by self determination theory are consistent with non-agent training studies in the domain of learner control, which assert that learner control over the pace, sequence, or presentation of material can be effective in increasing motivation and subject matter interest. According to Scheiter and Gerjets (2007), "involving learners in the decisions regarding their learning process should increase their interest in the content domain and foster their motivation to learn" (p 287). Alexander and Jetton (2003) note that "when making a case for hypermedia[14] and learning, researchers and educators often use words like self determination, choice, interest, and stimulation to capture the motivational qualities of hypermedia" (p. 220). These positions are consistent with Snow (1980) who noted, "feelings

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[13] Although the authors used the term "control" to describe the experimental manipulation in their study, the manipulation is consistent with what many researchers have termed "participation." For the sake of consistency, "participation" will be used when discussing this and similar studies.

[14] Hypermedia is defined as "online information with text, images, audio, and animation associated in a nonlinear web of associations, such that it could not be represented on paper" (Nelson, 1965, p. 96).

of self-efficacy and self-determination, and the skills involved in self-evaluation and the taking of independent responsibility, are enhanced by experience with control" (p. 152).

Cognitive Dissonance Theory

According to cognitive dissonance theory (Festinger, 1957), individuals are motivated to maintain consistency with regard to their attitudes and behaviors. When they are faced with inconsistencies, the theory predicts that it is easier to bring one's attitudes in line with behaviors, rather than the reverse. Later revisions of the theory provided elaboration of the nature of distressing inconsistencies; specifically, dissonance is thought to occur in the presence of *ego-based* inconsistencies, or discrepancies between the belief that a person is competent and the view that he or she has done something foolish (Thibodeau & Aronson, 1992). A multitude of studies have been conducted using a cognitive dissonance paradigm; based on this research, we know that by changing their original attitudes, individuals can view their behavior as consistent with what could be expected from a competent individual.

Research using the cognitive dissonance paradigm has demonstrated that people will often report liking an item more simply because they have chosen it. That is, if people are asked to choose between two equally attractive objects, they will subsequently rate the chosen object more positively. For example, Heine and Lehman (1997) gave college students the opportunity to rate CDs, then select between two equally-rated CDs to listen to. Later, when asked to re-rate the CDs, the chosen CD received much higher ratings. The rejected CD received lower ratings. Snibbe and Markus (2005) found similar patterns when they asked students to complete a questionnaire using either a pen they chose or a different, unchosen

pen. This phenomenon, referred to as *spreading alternatives* (Brehm, 1956), has been observed consistently in psychological research.

Similarity-Attraction Theory

Whereas procedural justice, self determination, and cognitive dissonance theories predict that the mere act of participating in the design of a pedagogical agent will directly improve learning outcomes, similarity-attraction theory suggests that participation can also affect outcomes indirectly by accommodating e-learners' preferences for tutors that resemble themselves.

The rationale behind providing learner control in the traditional sense (e.g., allowing e-learners to control the pace, sequence, and amount of exposure to the training material) is that learners may be able to make better decisions regarding their learning style and preferences than can an instructional designer. This same principle can be applied here; that is, learners may be the best judges of which personality or design characteristics in a tutor will be most amenable to them.

Practically speaking, this may mean that users design agents that resemble themselves. According to the *similarity-attraction hypothesis* (Byrne & Nelson, 1965) people are more attracted to others who match their personality and other characteristics. Because we know that human-computer interaction tends to mirror human-human interaction (Moon & Nass, 1996; Nass & Moon, 2000) it is reasonable to expect that learners will be more attracted to agents that are similar to themselves. As indicated earlier**,** past research supports the positive effect of similarity on computer users' technology acceptance during human-computer interactions (Nass et al., 1995; Nass & Lee, 2001).

In effect, allowing trainees to help design their pedagogical agent enables similarity, which should in turn positively influence variables such as trust, familiarity, attraction and, in turn, attention and interaction. To this end, Komiak and Benbasat (2006) demonstrated that trust, personalization perceptions, and familiarity influenced participants' willingness to use computerized recommender agents for online shopping. The researchers showed that familiarity with the recommender agent and perceived personalization positively affected trusting beliefs (both cognitive and affective), and that these trusting beliefs subsequently influenced intentions to adopt the technology and rely on its advice for decision-making. Although participation was not explicitly included in this study, one can assume that participation in the design of a particular technology would increase a person's familiarity with it. Further, participation should also have a positive effect on perceptions of personalization. That is, if a person has the opportunity to provide input into the nature of a technological tool, they should be more likely to believe that the tool has been personalized according to their preferences.

Theoretical Summary

To summarize the theoretical background for the current study, there are several distinct reasons that participation in agent design may improve training outcomes. First, participation has been shown to improve perceptions of fairness. Leventhal's (1980) components of procedural justice include the perception of voice, or input into the creation of processes. Uncertainty management theory (Lind & van den Bos, 2002) predicts that learners will be especially attuned to sources of unfairness in a virtual training setting.

Second, participation may improve training outcomes due to its effects on intrinsic motivation. Self determination theory (Deci & Ryan, 1985, Ryan & Deci, 2000) proposes that three basic human needs are at the foundation of individuals' self-motivation and fulfillment: the need for competence, the need for relatedness, and the need for autonomy. Individuals will be intrinsically motivated to the extent that these needs are met. Providing choice is thought to increase a person's sense of both autonomy and competence, and thus their intrinsic motivation (Deci & Ryan, 1985).

Third, learners will be more likely to believe that their agent is useful if they themselves have designed it, regardless of the actual quality of the agent. This argument is consistent with cognitive dissonance theory (Festinger, 1957), which predicts that if learners invest the effort required to design an agent, they will be motivated to believe the agent is useful in order to justify the effort expended. Similarly, past research has demonstrated that people often report liking an object more simply because they have chosen it (e.g., Snibbe & Markus, 2005).

Finally, learners may intentionally or unintentionally create tutors that are similar to themselves with regard to appearance or personality. The similarity-attraction paradigm (Byrne & Nelson, 1965) predicts that if learners interact with agents that are similar to them, they will be more likely to enjoy their interaction, and report liking the agent, than if they interact with dissimilar agents.

Effects of Participation in Agent Design

Past Research

While theory suggests that participation in the design of a pedagogical agent may have a number of beneficial effects for learners, controlled research testing this supposition is needed. Meta-analytic studies examining the effects of learner control in (non-agent) e-learning have demonstrated that control over the pace or sequence of material has a positive effect on learner motivation and reactions (Kraiger & Jerden, 2007); however, very little research has examined the effect of learner control over pedagogical agent characteristics.

One notable exception is a 2006 study conducted by Moreno and Flowerday, who empirically tested several aspects of learner choice with respect to agent design. First, they gave learners the option of learning either with or without the image of an animated colearner agent. Learners in the choice condition were asked, "Would you like to learn with just the voice of the agent, or both the voice and the image of the agent?" Second, they gave learners the opportunity to select the agent's gender and ethnicity. Learners in the choice condition were given the opportunity to view male and female agents with a variety of ethnicities, and select the one they would like to learn with. The researchers predicted that choice would improve reactions to the agent (as measured by helpfulness, motivation, and difficulty ratings). Choice was not found to impact learning, nor was there an interaction between choice and the gender/ethnicity similarity between the learner and agent. Similarly, no difference was found between the choice and no choice group with regard to program ratings, which the researchers measured with a combination of five items measuring agent helpfulness, desire to use the agent in the future, and training difficulty.

Moreno and Flowerday (2006) believe that this pattern of findings is due to the added distraction introduced by allowing learners to choose an agent. They noted, "When students

choose to learn with an APA of their same ethnicity, they focus their attention on how the APA represents them rather than on the instructional materials themselves" (p. 204). While this may explain the lack of effect for learning outcomes, it does not explain the lack of effect for the reactions measure. Perhaps, instead, this lack of effect was methodological; the researchers assessed reactions with only a few items, leaving open the possibility that the constructs were not adequately captured. The researchers used two items to measure helpfulness, one to measure desire for future interaction, and two to measure perceived training difficulty. No theoretical rationale was included for these measures, nor was reliability or validity information presented.

Another limitation to the Moreno and Flowerday (2006) study is their failure to control for the effects of the choices made by participants. Participants who were not able to choose their agent's ethnicity or gender were randomly assigned to an agent. This created a confound between choice and agent type, with participants in choice and non-choice conditions interacting with potentially different kinds of agents. Based on these limitations, the effect of choice in pedagogical design warrants further research employing alternative methods and measures to examine the phenomenon at hand.

Study Hypotheses

The current study will examine the effects of providing learners with participation into the design of their pedagogical agent, focusing on three characteristics that are frequently examined in the literature: appearance (gender, ethnicity), personality (empathy,

humor), and feedback-giving behavior (directiveness, normativeness[15]). A number of outcomes or criteria can and should be examined to determine the effects of participation on agent acceptance. Previous research in the domain of agent-assisted learning has examined a wide range of criteria, including learner self-efficacy, perceived usefulness of the agent, desire for future interaction, and learning gains (for reviews see Den & van Mulken, 2000; Gulz, 2005). Though examining all possible criteria of interest is generally not feasible in a single study, evaluating training on more than one level is advisable, to obtain a more complete picture of training effectiveness. Thus, a variety of training outcomes will be examined in this study. These outcomes, which are detailed in the following section, include trainee reactions (affective, utility, and engagement) as well as learning (post-training self-efficacy and declarative knowledge). Further, individual differences in desire for control will be explored as a moderator of the effects of participation on these outcomes. Figure 1 presents the model guiding this research.

Training Reactions

Reactions are trainees' attitudes toward the training, including both affective and utility components. *Affective* reactions refer to the degree to which trainees enjoyed themselves during training, whereas *utility* reactions refer to the trainee's cognitive assessment of whether the training was useful to them (Alliger et al., 1997). Finally, *engagement* has recently been included in assessments of trainee reactions as well (e.g., Brown, 2005). Engagement refers to the degree to which the training system holds trainees'

[15] Directive feedback refers to feedback that *tells* learners what to do next, rather than *suggests*; normative feedback refers to feedback that gives learners information about where they stand in relation to other learners.

attention throughout training. Engaged learners report being highly absorbed and immersed in the training tasks (Garris et al., 2002). Together, these three components of reactions can be thought of as the degree to which learners believe they have had a meaningful and satisfying learning experience (Sitzmann et al., 2008).

Trainee reactions are important outcomes of training for several reasons. First, trainees' attitudes about the training are likely to influence the probability that they will enroll in future courses, as well as the general reputation of the training program in an organization. These factors are typically of great interest to organizational decision-makers. Second, positive affect during training is associated with greater motivation, interest, and enthusiasm (Brown, 2005), all of which may facilitate the learning process.

Learner control is often purported to improve affective reactions, as well as willingness to attend additional training and intrinsic motivation (Kraiger & Jerden, 2007). Research regarding student attitudes has demonstrated that providing students with choices in their education results in higher intrinsic motivation and more positive attitudes about school (Weinert & Helmke, 1995). Other studies report that greater student autonomy leads to more positive emotions (Patrick, Skinner, & Connell, 1993) and a greater willingness to stay in school (Vallerand, Fortier, & Guay, 1997). Freitag and Sullivan (1995) found that matching the amount of content provided to learner preferences resulted in more positive student attitudes toward the training task.

With regard to utility reactions, it should be noted that the work of Nass et al. (1995) and Nass and Lee (2001) supports the assertion that users will view agents as more credible

and intelligent when they are similar than when they are different. Thus, from a similarity perspective, participation should have a positive effect on utility reactions.

Additionally, participation should prompt internal regulation (i.e., intrinsic motivation). Internal regulation is often associated with higher engagement and satisfaction (Ryan & Deci, 2006). Flowerday and Schraw (2003) found that readers who were given a choice of pace in a reading task had higher engagement than those who read at a researcher-set pace. A similar effect was found for readers who were given the choice between completing a crossword puzzle and writing an essay, compared to those who were assigned a task.

In light of the prior research and theory related to learner choice and control, participation in the design of a pedagogical agent is expected to improve training reactions, including affective reactions, utility reactions, and engagement.

Hypothesis 1: Participation in the design of a pedagogical agent's (H1a) appearance, (H1b) personality, and (H1c) feedback style will improve affective training reactions.

Hypothesis 2: Participation in the design of a pedagogical agent's (H2a) appearance, (H2b) personality, and (H2c) feedback style will improve utility training reactions.

Hypothesis 3: Participation in the design of a pedagogical agent's (H3a) appearance, (H3b) personality, and (H3c) feedback style will improve engagement.

Learning

The question of whether agents facilitate learning is fundamental, as the attainment of new knowledge and skills is one of the principal reasons why most training programs exist. Learning is a multidimensional outcome of training, and encompasses cognitive, skill-based,

and affective constructs (Kraiger, Ford, & Salas, 1993). Cognitive learning outcomes include declarative knowledge (i.e., statements of fact) and procedural knowledge (i.e., knowledge about how to perform a skill). Skill-based learning outcomes assess the fluidity and automaticity with which a person can perform a skill. Finally, affective learning includes attitudinal and motivational outcomes such as self-efficacy (Kraiger, Ford, & Salas, 1993). A given training program will typically focus on a subset of learning outcomes, depending on the nature of the training. The present study assesses both cognitive and affective learning outcomes.

Cognitive learning. A meta-analysis of the relationship between learner control and learning in a non-agent training context showed that in general, learner control has a positive but small effect on cognitive learning (Kraiger & Jerden, 2007). Learner control is more likely to result in improved learning when the outcomes are skill-based (rather than knowledge-based). The effect of learner control also appears to be more pronounced for learners with little prior experience with the subject matter. The type of control offered to learners is also a moderator; pace and sequence control tend to have positive effects on learning while content control does not.

Adding to these mixed results, there is inconsistent theoretical and empirical evidence for the idea that participation in the design of a pedagogical agent improves learning. In support of this view, learner control has typically been shown to increase reactions (Kraiger & Jerden, 2007). Positive reactions during training may then lead to learning gains, as learners become more engaged with the material and devote more energy to learning (Brown, 2005; Sitzmann et al., 2008). Thus, if participation increases intrinsic motivation, and

increases reactions, it may increase learning as well. This claim is supported by meta-analytic research by Brown (2005), who argued that the positive affect that comes from an enjoyable training experience will lead trainees to devote more time to training, thus leading to more learning.

However, despite these claims, most studies on the effects of participation have not been able to demonstrate an effect on learning. Schraw, Flowerday, and Reisetter (1998) examined the effect of choice on reading comprehension. Students in the choice group were permitted to select one of three texts they wished to read, while students in the denied-choice group were assigned a text. Although those in the choice group reported more interest in the text and more satisfaction with the research experience, the two groups did not differ on measures of cognitive performance (including a multiple-choice test of main ideas and essays included in the text). Similarly, Moreno and Flowerday (2006) found that choice over an agent's gender and ethnicity did not improve cognitive learning outcomes; in fact, learning was negatively affected by choice in some cases[16].

The mixed result obtained by Moreno and Flowerday (2006) lends credence to the assertion that offering learners too many choices may actually detract from cognitive learning. The *interference principle* states that under some circumstances, learners might direct their limited cognitive resources to an agent instead of the material being trained.

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[16] Moreno and Flowerday conducted analyses separately for learners who were paired with same-ethnicity and different-ethnicity agents. Of students who were paired with same-ethnicity agents, those who were offered a choice regarding the agent's gender and ethnicity had lower retention and transfer scores. For students who were paired with different-ethnicity agents, those who were offered a choice had higher retention and transfer ratings.

Although some view choice as a positive influence that leads to intrinsic motivation, others note that there are downsides to choice. For example, Iyengar and Lepper (2000) found that exposure to too many choices in a consumer setting discouraged purchase behavior[17]. Katz and Assor (2007) note that adding "seductive details" (i.e., entertaining but irrelevant sentences) to training may actually hurt student retention of the material, due to the additional demands placed on the student's working memory. More to the point, giving trainees too many choices regarding the appearance and behavior of a pedagogical agent may serve to distract them from the actual content of the training material if their attention is unduly directed towards the outcome of their choices during the training (e.g., a learner who chooses an extraverted agent may look for instances of extraverted behavior to confirm the choice made). Ryan and Deci (2006) concede that too many choices can serve to detract from self determination, noting, "…choice can, when meaningful, facilitate self determination, especially when it allows one to find that which one can wholeheartedly endorse. But choice can be constructed to do nothing of the sort, instead engendering confusion or fatigue" (p. 1577).

In short, there exist contradictory views on how agent design participation should affect learners' attention to the training material. Consequently, specific predictions concerning the effect of agent design participation on cognitive learning are difficult to justify. This issue will be explored here in the form of research questions in hopes of shedding light on the phenomenon. In addition to simply looking at the presence of a

[17] Despite their decreased purchase behavior, participants in that study reported greater enjoyment of the task when they had more options, even though they found it more difficult.

participation opportunity, the effects of the amount/degree of participation in pedagogical agent design will be examined. This will test the concern regarding the potentially detrimental effects of participation overload.

Research Question 1: How does participation in the design of a pedagogical agent's (RQ1a) appearance, (RQ1b) personality, and (RQ1c) feedback style influence cognitive learning?

Research Question 2: Does increasing the amount of participation in pedagogical agent design change the effect of participation on cognitive learning?

Affective learning. In contrast to cognitive learning, the anticipated effects of participation on affective learning outcomes such as post-training self-efficacy are more straightforward. Self-efficacy (Bandura, 1986) is the subjective assessment that one has the internal and/or external resources to cope with a given or hypothetical situation. In a training context, self-efficacy is often conceptualized as the confidence trainees have that they can successfully use the knowledge they obtained in training while on the job (Sitzmann et al., 2008). In other words, self-efficacy can be thought of as a measure of one's perceived ability to apply what he or she has learned. Sitzmann et al.'s meta-analysis demonstrated that post-training self-efficacy is the most useful self-report outcome in terms of predicting learning, especially procedural knowledge and delayed procedural knowledge (i.e., assessments conducted after some time period has passed).

As suggested previously, participation is believed to fulfill learners' need for competence. In other words, providing learners with participation opportunities sends the message that that they are capable of making effective choices in their own learning. Keller's

(1983) model of motivational instructional design incorporates this idea, proposing that learner control enhances students' self-efficacy. Drawing on attribution theory, Martin and Briggs (1986) suggest that students who have more control over their instructional material, pace, and sequence usually believe that the learning achievements are a result of their own ability. Chou and Liu (2005) found empirical support for this idea, demonstrating that students in a learner-controlled training environment (i.e., students could choose the time and location that they completed assignments) developed higher post-training self-efficacy than students in an identical course without learner control over time and location. Based on this theoretical and empirical evidence, agent design participation is expected to increase self-efficacy.

Hypothesis 4: Participation in the design of a pedagogical agent's (H4a) appearance, (H4b) personality, and (H4c) feedback style will increase post-training self-efficacy.

Desire for Control

A user's individual preference for having control is expected to moderate the relationship between participation and training outcomes. According to Kraiger and Jerden (2007), individual preferences for control moderate the effect of learner control on training outcomes: "Trainees who experience a level of control that corresponds to their preferred level will enjoy training more, engage in training longer, and be more likely to take more training in the future than trainees who receive too much or too little control" (p. 82). This proposition remains to be empirically tested; further, it refers to learner control over the pace, navigation, or content of the training, rather than control over the design of an agent.

In the social psychological literature, this preference for having control is referred to as *desire for control*[18] (DC; Burger & Cooper, 1979), defined as "the individual differences in the general level of motivation to control the events in one's life" (Burger & Cooper, 1979, p. 381). People who are high in desire for control tend to conform less to perceived norms and devote more effort to processing attributional information (Burger, 1992). Further, high-DC individuals are more prone to fall prey to illusory control manipulations (e.g., in gambling situations; Burger, 1984). Burger and Cooper (1979) theorized that these individual differences in people's motivation to be in control are related to motivations to feel masterful and competent. Thus, high-DC individuals are expected to be more reactive to the effects of participation opportunities.

Hypothesis 5: Desire for control will moderate the effects of participation on affective reactions, such that a high desire for control will strengthen the positive effects of participating in the design of a pedagogical agent's (H5a) appearance, (H5b) personality, and (H5c) feedback style on affective reactions.

Hypothesis 6: Desire for control will moderate the effects of participation on utility reactions, such that a high desire for control will strengthen the positive effects of participating in the design of a pedagogical agent's (H6a) appearance, (H6b) personality, and (H6c) feedback style on utility reactions.

Hypothesis 7: Desire for control will moderate the effects of participation on engagement, such that a high desire for control will strengthen the positive effects of

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[18] The authors also used the synonymous term, "desirability of control."

participating in the design of a pedagogical agent's (H7a) appearance, (H7b) personality, and (H7c) feedback style on engagement.

Hypothesis 8: Desire for control will moderate the effects of participation on post-training self-efficacy, such that a high desire for control will strengthen the positive effects of participating in the design of a pedagogical agent's (H8a) appearance, (H8b) personality, and (H8c) feedback style on post-training self-efficacy.

Research Question 3: Does desire for control moderate the effects of participation on declarative knowledge, such that the effects of participating in the design of a pedagogical agent's (RQ3a) appearance, (RQ3b) personality, and (RQ3c) feedback style on declarative knowledge are particularly pronounced for those with a relatively high desire for control?

METHOD

Design

This experiment employed a 2 X 4 fully crossed design. The first independent variable, participation status, had two levels: participation and no participation (i.e., the control group) which represented those who did and did not participate in the design of their pedagogical agent respectively. The second independent variable, participation type, had four levels: appearance participation (AP), personality participation (PP), feedback style participation (FP), and multiple participation (MP; appearance, personality, and feedback style). A yoked control group design was used; that is, four "no participation" control groups were created to correspond to the four (AP, PP, FP, and MP) experimental groups. Each participant in a given control group was assigned an agent using the characteristics chosen by

a member of the corresponding experimental group. This yielded a total of eight experimental conditions.

The yoking process proceeded as follows. Because it was necessary for each experimental participant to complete the study before his or her yoked control, participants were assigned to either the participation or no participation condition based on the order in which they signed up. The first person to sign up for the study was assigned to the participation condition, the second person to sign up was his or her yoked control, the third volunteer was assigned to the participation condition, and so forth. Through the use of a random number generator, each dyad was then randomly assigned to the AP, PP, FP, or MP condition.

This yoked control group design was chosen in order to control for the effects of the agent's characteristics/quality on reactions and learning. In other words, it was important to remove possible confounds from the effects of particular choices made on the quality of the training. For example, if most experimental participants chose "funny" agents and an unanticipated effect of "funny" agents existed, it would be important to ensure that members of participation and no participation groups were equally likely to interact with a funny agent.

Participants

Participants for this study were 256 undergraduates at a large Southeastern university who volunteered in order to receive course credit. Power analyses conducted for two-level

designs (PINT software; Snijders & Bosker, 1993) revealed that this sample size was sufficient to ensure power of .8.[19]

Procedure

Participants signed up for this experiment via Experimetrix, the psychology department's online research participation management web site, in order to gain course credit. Upon signup, participants completed an informed consent form and were directed to a preliminary questionnaire measuring desire for control, participant demographics, and supplemental constructs not included in the current study. Participants were then given a random identifier, assigned to a condition (as detailed above), and given the opportunity to sign up for a training session.

All training and data collection took place online from a location of the participant's choosing. First, a link was made available that directed participants to an informed consent form. They were then directed to a web page containing a set of instructions. The web page introduced the pedagogical agent by stating, "You will be completing your training today with a computerized tutor, an intelligent agent that has been designed to help you with this training. Your tutor's name is PJ. PJ will communicate with you by using this chat window."

Participants in the experimental conditions then viewed a web site (content shown in Appendix A.1) that asked them to make a series of selections regarding the appearance, personality, or feedback style of their agent, or all of the above characteristics. Participants in

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[19] The PINT program calculates standard errors of regression coefficients and variance components, given means, variances, and covariances for each independent variable. These standard errors can then be used to estimate power using the formula (effect size / standard error) $\approx (z1\text{-}\alpha + z1\text{-}\beta) = (z1\text{-}\alpha - z\beta)$ where $z\alpha$, $z\beta$ and $z1\text{-}\beta$ are the z-scores (values from the standard normal distribution) associated with the indicated α and β-values (Snijders & Bosker, 1993).

the control conditions were given a preliminary statement to read that described their pedagogical agent with regard to appearance, personality, or behavior, but were not given the chance to provide input on these characteristics. See Appendix A.2 for an example of the materials shown to the control group.

In the AP, PP, and FP conditions, there was a need for the experimenters to determine the values of the nonparticipation categories. For example, although experimental participants in the AP condition chose the agents appearance, the experimenter needed to determine the agent's personality and feedback style. The nonparticipation categories were fixed at set values as follows. First, a list of all possible combinations of nonparticipation characteristics was generated for each of the three conditions. Then, a combination/sequence was randomly chosen, without replacement, for each participating dyad within a condition. This process repeated itself (i.e., the list of all possible combinations was reintroduced) once all possible combinations had been implemented within a condition. Sampling without replacement was conducted to prevent oversampling of any one combination of characteristics.

After the participants made their selections or read the descriptions, they were directed to a training web site. After the training, participants were directed to a set of questionnaires assessing their post-training reactions, learning, and manipulation checks. Finally, participants viewed a debriefing page and were asked to enter their email address for experimental credit purposes (this identifying information was not linked to the other data collected in this study).

Training Program

All participants worked on a one-hour Excel training activity, with six modules selected to be moderately difficult (e.g., Pivot Tables, formulas). The training was adapted from Microsoft's Office Online Excel 2007 training courses (Microsoft, 2008). For each module, participants first viewed a series of web pages with text and graphic content (i.e., Excel screen shots and textual explanations). Next, they were given a set of five review questions to answer. Based on their performance, the agent either advised them to go back and review the content, or advance to the next module. At this point, the agent's characteristics determined the nature of their feedback and other comments; for example, a learner who selected an empathetic agent might see the message "You must be really excited about that score!" while a user who did not select the empathetic option might see the message "That score demonstrates mastery." Further detail about the agent's statements can be found below. Upon completion of the six modules, participants were directed to a final declarative knowledge test. An interactive menu was used, such that the participants could revisit each module as many times as they wished; however, once they proceeded to the test, the modules were disabled so they could not return.

The training program was equipped to track the total amount of time each participant spent on each module, the time spent designing the agent, and the number of visits to each module.

Pedagogical Agent

The pedagogical agent avatars were created using the Haptek PeoplePutty system (Haptek, 2003) and an appropriate avatar was produced according to the experimental participants' specified preferences. The agent followed a script, automatically generated

according to the menu options selected. The agent provided each statement in a chat window displayed to the right of the training content (see Appendix A.3 for the layout of the training web site). The statements were adapted from previous literature when possible, and piloted to ensure they conveyed the intended characteristics. Five graduate students were asked to read each statement and select the adjective that best described it using the questionnaire shown in Appendix A.1 (i.e., the same questionnaire participants viewed to make their selections). Items that had less than 80% agreement for a particular category were discarded, and additional items were written and pilot-tested in this manner until each category descriptor had 4-6 corresponding statements. Example scripts are given in Appendix A.4. An example avatar image is displayed in Appendix A.5.

Measures

A complete list of the questionnaire items administered in this study, separated by construct, is presented in Appendix A.7. All items used a 5-point Likert scale with anchors *strongly disagree-strongly agree* unless otherwise noted. For scales combining items with different anchors (e.g., 5-point scales and 10-point scales), scores will be standardized (i.e., converted to z-scores) before aggregation so values are comparable.

Appearance manipulation check (alpha = XX) was measured with two items created for this study, for example "I was able to control the way my agent looked."

Personality manipulation check (alpha = XX) was measured with two items created for this study, for example "I was able to control my agent's personality."

Feedback style manipulation check (alpha = XX) were measured with two items created for this study, for example, "I was able to control the way my agent delivered feedback."

Pre-training Excel knowledge (alpha = XX) was measured with four items created for this study. This measure was used as a covariate in analyses involving declarative knowledge.

Affective reactions (alpha = XX) were measured with three items taken from Thompson et al. (in press), for example "I am satisfied with the Excel training program," and four additional unpublished items developed by the researchers, for example, "Participating in this web-based training program was a rather negative experience for me (reverse-scored)."

Utility reactions (alpha = XX) were measured with four items created by the researchers, for example, "This web-based training program was a worthwhile learning experience," and the five-item Value/Usefulness subscale adapted from the Intrinsic Motivation Inventory (Ryan, 2008, alpha = XX; example item, "I believe this training could be of some value to me."). These five items were rated on a seven-point Likert scale with anchors *not at all true of me* to *very true of me*.

Engagement (alpha = XX) was measured with two items taken from Brown (2005): "I found that I had been reading and then didn't know what it was all about," and "I often missed important points because I was thinking of other things" as well as the Interest/Enjoyment scale of the Intrinsic Motivation Inventory (seven items, alpha = XX): for example, "This activity did not hold my attention at all (reverse-scored)." These seven

items were rated on a seven-point Likert scale with anchors *not at all true of me* to *very true of me*.

Post-training self-efficacy was measured with four items adapted from Guthrie and Schwoerer (1994) (alpha = XX), for example, "I will be able to apply the skills I learned in this training," and six items created to reflect efficacy for specific Excel functions, adapted from Gist, Schwoerer, and Rosen (1989), for example, "I can write a formula to sum a list of numbers." These six items were rated with a 10-point scale with anchors *not at all confident* to *very confident.*

Declarative knowledge was measured with a 22-item multiple choice test taken directly from the Microsoft Online Training program (Microsoft, 2008). (mean item difficulty = XX, range = XX). These items are included in the Microsoft training program as knowledge checks after each module.

Perceived similarity (alpha = XX) was measured with six items created for the current study.

Actual similarity (alpha = XX) was measured with four items created for this study.

Desire for control was measured with 20 items from Burger and Cooper's (1979) Desire for Control Scale (alpha = XX), for example, "I prefer a job where I have a lot of control over what I do and how I do it." This scale has five subscales: (a) general desire (5 items); (b) decisiveness (5 items); (c) preparation-prevention (4 items); (d) avoidance of dependence (2 items); and (e) leadership (4 items). Only the general and decisiveness subscales were analyzed in the current study.

Demographic/background measures included age, gender, ethnicity, class standing, and GPA.

Supplementary measures not included for the purpose of this study were also administered. These include satisfaction with the technology and reactions to the agent. These items can be found in Appendix A.8.

PROPOSED ANALYSIS

Multilevel modeling (MLM; Raudenbush & Bryk, 2002) was used to test the hypotheses in this study. MLM is an extension of ordinary-least-squares (OLS) regression that acknowledges effects on the dependent variable from both the individual level and higher levels. For example, in the current study, training reactions can be expressed as a function of participation status (individual level, level 1) as well as characteristics of the dyad to which a person belongs (group level, level 2). In this study, level 2 effects include both the condition to which a dyad is assigned, as well as particular features of the agent that the dyad interacts with. OLS regression cannot account for level 2 variables. In the current study, this is a concern, given the yoked control group design. That is, individuals within yoked dyads will be expected to be more similar than individuals across dyads, violating the assumptions of independence of observations and uncorrelated residuals in OLS regression. MLM is an effective way of addressing these violations (Raudenbush & Bryk, 2002).

Repeated measures (RM) ANOVA analyses are sometimes used to address dependency of observations. However, in the current study, MLM provides an advantage over RM-ANOVA analyses for several reasons. In RM-ANOVA, a difference score is calculated (e.g., the difference between an experimental participant and his/her yoked

control's knowledge test score); this difference score becomes the observation of interest. This difference score, however, is subject to several serious problems. First, the difference score is much more unreliable than individual scores. This can be illustrated clearly by considering the basic form of an observed score under classical test theory, in which $X = T + e$ (X = observed score, T = true score, e = random error component). When a difference score is calculated, both random error components remain in the resulting $X_1 - X_2$ term, while much of the true score is eliminated (Cronbach & Furby, 1970).

Second, RM-ANOVA is subject to several data restrictions, such as balanced data (i.e., an equal number of observations in each cell), which can lead to a large amount of wasted data. MLM is not subject to these restrictions; that is, if one member of a dyad has missing data on a variable, the other member's data can still be used, where in RM-ANOVA that data point could not be used. Finally, because the dyad-level (level 2) difference score is the observation of interest in RM-ANOVA, individual-level information, including moderators such as Desire for Control, cannot be included in RM-ANOVA analyses. Therefore, MLM was the most appropriate analytical strategy for the current study.

Prior to conducting multilevel analyses, participation type and participation status were both dummy-coded. For all equations listed below, analyses were run separately for each DV of interest.

The six sets of equations used to test Hypotheses 1-4 and Research Questions 1 and 2 are listed below. The first equation, the fully unconditional model, contains no predictors at level 1 or level 2 and estimated the amount of variability between and within dyads. Put

another way, this model answered the question, "How much of the total variability in scores is between dyads? How much is within dyads?"

$$\text{Level 1:} \quad DV_{ij} = \beta_{0j} + r_{ij} \qquad [1]$$
$$\text{Level 2:} \quad \beta_{0j} = \gamma_{00} + u_{0j}$$

Where DV_{ij} is the score on the dependent variable for dyad *j* and person *i*, β0j is the intercept, and r_{ij} is the individual-level residual, or the difference between the dyad-level intercept and person *i*'s observed score. The combined residuals for the sample were then used to estimate σ^2, or within-dyad variability. γ_{00} is the grand mean of the dependent variable, and u_{0j} is the random effect at level 2 (i.e., the amount of variability at level 2, τ_{00}). From this model, the intraclass correlation coefficient was calculated to determine the percentage of variability that is between dyads, as follows:

$$\rho = \tau_{00} / (\tau_{00} + \sigma^2) \qquad [2]$$

A nonsignificant level of between-dyad variation would show that on average, individual scores from people within a dyad were no more similar than individual scores from people in different dyads, indicating that multilevel modeling was not required. That is, there was not a sufficient level of within-group homogeneity to inflate standard errors and bias significance tests in OLS regression. If this was the case, OLS regression was used for the remainder of hypothesis tests detailed below (i.e., all predictors will be treated as level 1; differences between the participation and no participation conditions will be tested without taking into account the particular dyad to which participants belonged).

To determine whether participation has an effect on the DVs of interest (i.e., Hypotheses 1-4 and Research Questions 1 and 2), the following equations for a random coefficients regression model will be tested. These models answer the questions, "Does participation status affect the DV?" "Are there mean differences across dyads in the level of the DV?" and "Does participation have different effects on the DV depending on the dyad a person belongs to?"

$$\begin{aligned} &\text{Level 1:} \quad DV_{ij} = \beta_{0j} + \beta_{1ij}(\text{Part. Status}) + r_{ij} \\ &\text{Level 2:} \quad \beta_{0j} = \gamma_{00} + u_{0j} \\ &\qquad\quad \beta_{1j} = \gamma_{10} + u_{1j} \end{aligned} \qquad [3]$$

Where β_{1ij} represents to effect of participation status on the DV, u_{0j} is tested to see if there is variance in the level of the DV across dyads, and u_{1j} is tested to see if there is variance across dyads with respect to the effect of participation status. Assuming an effect of participation status, the following models would then be tested, to examine the cross-level interactions between participation type and participation status. That is, if it determined that dyads do differ with respect to the effects of participation, or the average level of the DV, the model below will attempt to explain that variability with the introduction of participation type as a predictor. This will determine whether the effect of participation varies across participation type (e.g., AP, PP, FP, and MP).

$$\begin{aligned} &\text{Level 1:} \quad DV_{ij} = \beta_{0j} + \beta_{1ij}(\text{Part. Status}) + r_{ij} \\ &\text{Level 2:} \quad \beta_{0j} = \gamma_{00} + \gamma_{01}(\text{Part. Type}) + u_{0j} \\ &\qquad\quad \beta_{1j} = \gamma_{10} + \gamma_{11}(\text{Part.Type}) + u_{1j} \end{aligned} \qquad [4]$$

Where γ_{01} represents the effect of participation type on the average level of the DV, and γ_{11} represents the effects of different participation types (dummy-coded) on the relationship between participation status and the DV (i.e., Hypotheses 1-4, Research Questions 1 and 2).

Hypotheses 5-8 and Research Question 3 predicted an interaction between participation and desire for control (DC) on reactions and learning. In order to test each hypothesis/question, the following models were tested. Five sets of models were run, one to test each hypothesis or research question. These models included the addition of DC and the interaction between DC and participation status as predictors at level 1. At level 2, no new predictors were added. These models answered the questions, "Does desire for control moderate the effects of participation on each DV?" "Does the nature of the interaction change based on the dyad a person belongs to?" and "Does the nature of the interaction change depending on the type of participation (AP, PP, FP, MP) allowed?"

$$\text{Level 1:} \quad DV_{ij} = \beta 0j_j + \beta_{1i}(\text{Part. Status}) + \beta_{2ij}(\text{DC}) + \beta_{3ij}(\text{DC*Part. Status}) + r_{ij} \qquad [5]$$

$$\text{Level 2:} \quad \beta_{0j} = \gamma_{00} + \gamma_{01}(\text{Part. Type}) + u_{0i}$$
$$\beta_{1i} = \gamma_{10} + \gamma_{11}(\text{Part. Type}) + u_{1i}$$
$$\beta_{2i} = \gamma_{20} + \gamma_{21}(\text{Part. Type}) + u_{2i}$$
$$\beta_{3i} = \gamma_{30} + \gamma_{31}(\text{Part. Type}) + u_{3i}$$

Where β_{3ij} represents the effect of the interaction of DC and participation status on the DV, and γ_{31} represents the effect of different types of participation on the interaction between DC and participation status.

Appendix A.1.

Participation Manipulation Questionnaire

You will be working with a computerized tutor named PJ to complete your training. We want to give you the opportunity to participate in the design of PJ. Fill out your preferences below, and PJ will be personalized accordingly.

Appearance

1. What gender would you like PJ to be?

Male	Female

2. What ethnicity would you like PJ to be?

Caucasian	African American	Latino	Asian

Personality

1. Would you like PJ to make jokes or be serious?

Make jokes	Be serious

2. Would you like PJ to be empathetic and compassionate, or professional and unemotional?

Empathetic/Compassionate When you do well, PJ will be proud of you. When you do poorly, PJ will know that you are frustrated.	Professional/Unemotional PJ will not display any emotion based on your performance.

Feedback Style

1. Would you like PJ to tell you how you are performing compared to others, or compared to your own past performance?

Compared to others	Compared to myself
PJ might tell you that you are in the top 30% of all trainees, or that people who have learning habits like yours tend to benefit from extra practice in a particular area.	PJ might notice when you are improving compared to earlier tasks, or remind you that last time you skipped a page, your score suffered.

2. How should PJ offer you feedback? Would you like PJ to tell you what you should do next, or offer suggestions and let you decide?

Tell me what to do	Give me suggestions
PJ might tell you that you should definitely go back and review a page before continuing.	PJ might ask you if you want to go back and review any material.

Appendix A.2.
No Participation (Control) Manipulation Description

You will be working with a computerized tutor named PJ to complete your training. PJ has been pre-designed according to the characteristics described below.

Appearance

3. What gender will PJ to be?

Male ✖	Female

4. What ethnicity will PJ be?

Caucasian ✖	African American	Latino	Asian

Personality

3. Will PJ make jokes or be serious?

Make jokes	Be serious ✖

4. Will PJ be empathetic and compassionate, or professional and unemotional?

Empathetic/Compassionate ✖ When you do well, PJ will be proud of you. When you do poorly, PJ will know that you are frustrated.	Professional/Unemotional PJ will not display any emotion based on your performance.

Feedback Style

3. Will PJ tell you how you are performing compared to others, or compared to your own past performance?

Compared to others ✖	Compared to myself

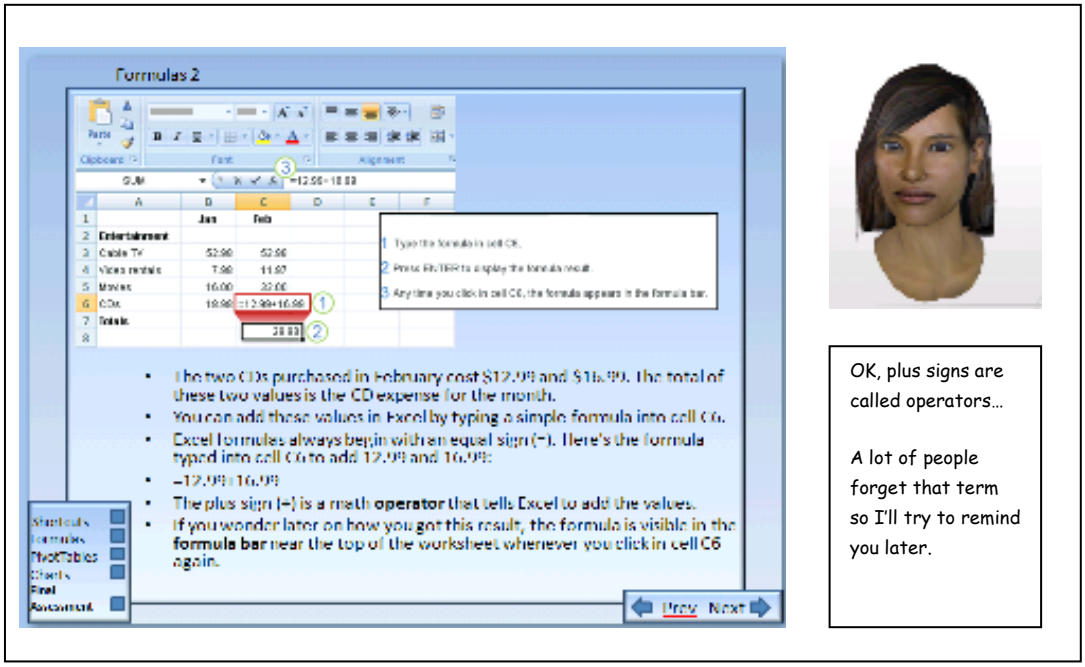
PJ might tell you that you are in the top 30% of all trainees, or that people who have learning habits like yours tend to benefit from extra practice in a particular area.	PJ might notice when you are improving compared to earlier tasks, or remind you that last time you skipped a page, your score suffered.

4. How will PJ deliver feedback? Will PJ tell you what you should do next, or offer suggestions and let you decide?

Tell me what to do PJ might tell you that you should definitely go back and review a page before continuing.	Give me suggestions  PJ might ask you if you want to go back and review any material.

Appendix A.3.

Training Module Layout



Appendix A.5.
Example Scripts

Dimension		Positive	Negative
Feedback	Normative	About ten percent of people get a score like yours. You're in the top 25% of trainees. You're doing above average for people with your background.	You're in the lower 30% of trainees with your background. You're not doing as well as other people have.
	Self-Referenced	You're improving. You did better than last time.	You're not doing as well as before. You're doing worse than last time.
	Directive	You should really go back and review [module page] before you continue.	
	Non-Directive	Would you like to revisit [module page] to learn more about this topic?	
Personality	Funny	Are you sure you aren't an Excel expert in disguise? A few more of these and you'll be ready to teach the class yourself! Here's a top-secret tip: [give hint]	Sure you're having a hard time, but at least you have a body.
	Serious	Hint: [give hint]	

	Empathetic	Wow, you must be really proud of that score! This must be exciting for you! This module looks like it will be fun for you!	It must be frustrating to get a low score. I bet you're getting bored.
	Non-empathetic	That is an excellent score.	You are not demonstrating mastery.

Appendix A.6.

Avatar Examples

Caucasian female

Caucasian male

African American male

Asian male

Appendix A.7.

Post-Training Questionnaire Items

Item	Response Scale	Construct (and Source)
I was able to control the way my agent looked	5 point Likert scale (strongly disagree—strongly agree)	Manipulation Check (new item)
My preferences we taken into account in creating PJ's appearance	5 point Likert scale (strongly disagree—strongly agree)	Manipulation Check (new item)
I was able to control my agent's personality (e.g., whether PJ was funny, empathetic, etc.)	5 point Likert scale (strongly disagree—strongly agree)	Manipulation Check (new item)
My preferences we taken into account in creating PJ's personality (e.g., whether PJ was funny, empathetic, etc.)	5 point Likert scale (strongly disagree—strongly agree)	Manipulation Check (new item)
I was able to control the way my agent delivered feedback (e.g., whether PJ told me to take certain steps or suggested ideas)	5 point Likert scale (strongly disagree—strongly agree)	Manipulation Check (new item)
My preferences we taken into account in creating PJ's feedback style (e.g., whether PJ told me to take certain steps or suggested ideas)	5 point Likert scale (strongly disagree—strongly agree)	Manipulation Check (new item)

Item	Response Scale	Construct (and Source)
I thought PJ was similar to me in terms of personality	5 point Likert scale (strongly disagree—strongly agree)	Perceived Similarity (new item)
I thought PJ was similar to me in terms of appearance	5 point Likert scale (strongly disagree—strongly agree)	Perceived Similarity (new item)
I thought PJ was similar to me in terms of how we each deliver feedback to others	5 point Likert scale (strongly disagree—strongly agree)	Perceived Similarity (new item)
PJ and I share many personality characteristics	5 point Likert scale (strongly disagree—strongly agree)	Perceived Similarity (new item)
PJ and I share physical appearance characteristics	5 point Likert scale (strongly disagree—strongly agree)	Perceived Similarity (new item)
PJ and I have a shared feedback delivery style	5 point Likert scale (strongly disagree—strongly agree)	Perceived Similarity (new item)
I am satisfied with the Excel training program	5 point Likert scale (strongly disagree—strongly agree)	Affective Reactions (Thompson, Sebastianelli, & Murray, in press)
Overall, I enjoyed this web-based training	5 point Likert scale (strongly disagree—strongly agree)	Affective Reactions (Thompson, Sebastianelli, & Murray, in press)
If given the opportunity, I would take part in another web-based training program like this one	5 point Likert scale (strongly disagree—strongly agree)	Affective Reactions (Thompson, Sebastianelli, & Murray, in press)

Item	Response Scale	Construct (and Source)
Participating in this web-based training program was a rather negative experience for me (reverse-scored)	5 point Likert scale (strongly disagree—strongly agree)	Affective Reactions (new item)
This training program was fun	5 point Likert scale (strongly disagree—strongly agree)	Affective Reactions (new item)
I disliked this training program (reverse-scored)	5 point Likert scale (strongly disagree—strongly agree)	Affective Reactions (new item)
I couldn't wait for this training program to be over (reverse-scored)	5 point Likert scale (strongly disagree—strongly agree)	Affective Reactions (new item)
This web-based training program was a worthwhile learning experience	5 point Likert scale (strongly disagree—strongly agree)	Utility Reactions (new item)
I would have learned a lot more if someone had done a better job creating this training program (reverse-scored)	5 point Likert scale (strongly disagree—strongly agree)	Utility Reactions (new item)
As a result of this training program, I gained a greater understanding of Excel	5 point Likert scale (strongly disagree—strongly agree)	Utility Reactions (new item)
I learned very little during this web-based training program (reverse-scored)	5 point Likert scale (strongly disagree—strongly agree)	Utility Reactions (new item)

Item	Response Scale	Construct (and Source)
I believe this training could be of some value to me	7 point Likert scale (not at all true of me—somewhat true of me—very true of me)	Utility Reactions; Value/Usefulness Scale of Intrinsic Motivation Inventory (Deci, 2008)
I think that completing this training is useful for learning Excel	7 point Likert scale (not at all true of me—somewhat true of me—very true of me)	Utility Reactions; Value/Usefulness Scale of Intrinsic Motivation Inventory (Deci, 2008)
I would be willing to do this again because it has some value to me	7 point Likert scale (not at all true of me—somewhat true of me—very true of me)	Utility Reactions; Value/Usefulness Scale of Intrinsic Motivation Inventory (Deci, 2008)
I believe completing this training could be beneficial to me	7 point Likert scale (not at all true of me—somewhat true of me—very true of me)	Utility Reactions; Value/Usefulness Scale of Intrinsic Motivation Inventory (Deci, 2008)
I think this is an important training program.	7 point Likert scale (not at all true of me—somewhat true of me—very true of me)	Utility Reactions; Value/Usefulness Scale of Intrinsic Motivation Inventory (Deci, 2008)
I found that I had been reading and then didn't know what it was all about	5 point Likert scale (strongly disagree—strongly agree)	Engagement (Brown, 2005)
I often missed important points because I was thinking of other things	5 point Likert scale (strongly disagree—strongly agree)	Engagement (Brown, 2005)
I enjoyed doing this activity very much	7 point Likert scale (not at all true of me—somewhat true of me—very true of me)	Engagement; Interest/ Enjoyment Scale of Intrinsic Motivation Inventory (Deci, 2008)

Item	Response Scale	Construct (and Source)
This activity was fun to do	7 point Likert scale (not at all true of me—somewhat true of me—very true of me)	Engagement; Interest/ Enjoyment Scale of Intrinsic Motivation Inventory (Deci, 2008)
I thought this was a boring activity (reverse-scored)	7 point Likert scale (not at all true of me—somewhat true of me—very true of me)	Engagement; Interest/ Enjoyment Scale of Intrinsic Motivation Inventory (Deci, 2008)
This activity did not hold my attention at all (reverse-scored)	7 point Likert scale (not at all true of me—somewhat true of me—very true of me)	Engagement; Interest/ Enjoyment Scale of Intrinsic Motivation Inventory (Deci, 2008)
I would describe this activity as very interesting	7 point Likert scale (not at all true of me—somewhat true of me—very true of me)	Engagement; Interest/ Enjoyment Scale of Intrinsic Motivation Inventory (Deci, 2008)
I thought this activity was quite enjoyable	7 point Likert scale (not at all true of me—somewhat true of me—very true of me)	Engagement; Interest/ Enjoyment Scale of Intrinsic Motivation Inventory (Deci, 2008)
While I was doing this activity, I was thinking about how much I enjoyed it	7 point Likert scale (not at all true of me—somewhat true of me—very true of me)	Engagement; Interest/ Enjoyment Scale of Intrinsic Motivation Inventory (Deci, 2008)
I am confident that I can succeed in using Excel.	5 point Likert scale (strongly agree—strongly disagree)	Self-Efficacy (Guthrie & Schwoerer, 1994)
I will do well using Excel.	5 point Likert scale (strongly disagree—strongly agree)	Self-Efficacy (Guthrie & Schwoerer, 1994)

Item	Response Scale	Construct (and Source)
I will be able to apply the skills used in training.	5 point Likert scale (strongly disagree—strongly agree)	Self-Efficacy (Guthrie & Schwoerer, 1994)
I will be able to apply what I learned in training.	5 point Likert scale (strongly disagree—strongly agree)	Self-Efficacy (Guthrie & Schwoerer, 1994)
I am capable of writing a formula for addition.	10-point scale, *not at all confident* to *very confident*	Self-Efficacy (Gist, Schwoerer, & Rosen, 1989)
I am capable of using keyboard shortcuts to navigate in Excel.	10-point scale, *not at all confident* to *very confident*	Self-Efficacy (Gist, Schwoerer, & Rosen, 1989)
I am capable of creating a PivotTable to organize information in Excel.	10-point scale, *not at all confident* to *very confident*	Self-Efficacy (Gist, Schwoerer, & Rosen, 1989)
I am capable of creating a chart to display information in Excel.	10-point scale, *not at all confident* to *very confident*	Self-Efficacy (Gist, Schwoerer, & Rosen, 1989)
Others usually know what is best for me.	5 point Likert scale (strongly disagree—strongly agree)	Desire For Control (Burger & Cooper, 1979) ; Avoidance Subscale
I wish I could push many of life's daily decisions off on someone else.	5 point Likert scale (strongly disagree—strongly agree)	Desire For Control (Burger & Cooper, 1979) ; Avoidance Subscale
I enjoy making my own decisions.	5 point Likert scale (strongly disagree—strongly agree)	Desire For Control (Burger & Cooper, 1979); Decisiveness Subscale

Item	Response Scale	Construct (and Source)
I consider myself to be generally more capable of handling situations than others are	5 point Likert scale (strongly disagree—strongly agree)	Desire For Control (Burger & Cooper, 1979); Decisiveness Subscale
There are many situations in which I would prefer only one choice rather than having to make a decision.	5 point Likert scale (strongly disagree—strongly agree)	Desire For Control (Burger & Cooper, 1979); Decisiveness Subscale
I like to wait and see if someone else is going to solve a problem so I don't have to be bothered by it.	5 point Likert scale (strongly disagree—strongly agree)	Desire For Control (Burger & Cooper, 1979); Decisiveness Subscale
I prefer to avoid situations where someone else has to tell me what it is I should be doing.	5 point Likert scale (strongly disagree—strongly agree)	Desire For Control (Burger & Cooper, 1979); Decisiveness Subscale
I prefer a job where I have a lot of control over what I do and how I do it.	5 point Likert scale (strongly disagree—strongly agree)	Desire For Control (Burger & Cooper, 1979); General Subscale
I enjoy being able to influence the actions of others	5 point Likert scale (strongly disagree—strongly agree)	Desire For Control (Burger & Cooper, 1979); General Subscale
I enjoy political participation because I want to have as much of a say in running government as possible.	5 point Likert scale (strongly disagree—strongly agree)	Desire For Control (Burger & Cooper, 1979); General Subscale
I try to avoid situations where someone else tells me what to do.	5 point Likert scale (strongly disagree—strongly agree)	Desire For Control (Burger & Cooper, 1979); General Subscale

Item	Response Scale	Construct (and Source)
I enjoy having control over my own destiny	5 point Likert scale (strongly disagree—strongly agree)	Desire For Control (Burger & Cooper, 1979); General Subscale
I would prefer to be a leader rather than a follower	5 point Likert scale (strongly disagree—strongly agree)	Desire For Control (Burger & Cooper, 1979); Leadership Subscale
I would rather someone else took the leadership role when I'm involved in a group project	5 point Likert scale (strongly disagree—strongly agree)	Desire For Control (Burger & Cooper, 1979); Leadership Subscale
I'd rather run my own business and make my own mistakes than follow someone else's orders	5 point Likert scale (strongly disagree—strongly agree)	Desire For Control (Burger & Cooper, 1979); Leadership Subscale
When it comes to orders, I would rather give them than receive them	5 point Likert scale (strongly disagree—strongly agree)	Desire For Control (Burger & Cooper, 1979) Leadership
I am careful to check everything on an automobile before I leave on a long trip.	5 point Likert scale (strongly disagree—strongly agree)	Desire For Control (Burger & Cooper, 1979); Preparation Subscale
I like to get a good idea of what a job is all about before I begin.	5 point Likert scale (strongly disagree—strongly agree)	Desire For Control (Burger & Cooper, 1979); Preparation Subscale
When I see a problem I prefer to do something about it rather than sit by and let it continue	5 point Likert scale (strongly disagree—strongly agree)	Desire For Control (Burger & Cooper, 1979); Preparation Subscale

Item	Response Scale	Construct (and Source)
When driving, I try to avoid putting myself in situations where I could be hurt by someone else's mistake.	5 point Likert scale (strongly disagree—strongly agree)	Desire For Control (Burger & Cooper, 1979); Preparation Subscale
Imagine you are tutoring a friend and need to give them some feedback about their performance. Which option best represents the manner you would prefer to use when giving them feedback about their performance?	5 point scale, 1 = completely prefer to give directive feedback (e.g., you must go back and review your notes) to 5 (completely prefer to give non-directive feedback (e.g., you might want to consider reviewing your notes)	Directiveness Preference
Which option best represents the manner you would prefer to use when giving them feedback about their performance?	5 point scale, 1 = completely prefer to give normative feedback (e.g., you are doing better than most people in the class) to 5 (completely prefer to give non-normative feedback (e.g., you are improving compared to last time we met)	Normativeness Preference
Which option best represents the manner you would prefer to use overall when acting as their tutor?	5 point scale 1 = I completely prefer to remain serious and professional to 5 = I completely prefer to use humor and jokes	Humor Preference

Item	Response Scale	Construct (and Source)
Which option best represents the manner you would prefer to use overall when acting as their tutor?	5 point scale 1 = I completely prefer to show empathy and emotion to 5 = I completely prefer to refrain from showing emotion	Empathy Preference
How old are you?	Open-ended	Background item
What is your gender?	Male; Female; Prefer not to answer	Background item
What is your ethnicity?	African American/Black; Caucasian; Hispanic/Latino; Asian/Pacific Islander; Other; Prefer not to answer	Background item
What is your GPA?	Open-ended	Background item
What is your class standing?	Freshman; Sophomore; Junior; Senior; Non-Traditional Student; Other (please specify)	Background item
I already know how to use PivotTables to organize information in Microsoft Excel 2007	5 point Likert scale (strongly disagree—strongly agree)	Pre-training Knowledge (new item)
I already know how to use keyboard shortcuts to navigate in Microsoft Excel 2007	5 point Likert scale (strongly disagree—strongly agree)	Pre-training Knowledge (new item)

Item	Response Scale	Construct (and Source)
I already know how to use charts to display information in Microsoft Excel 2007	5 point Likert scale (strongly disagree—strongly agree)	Pre-training Knowledge (new item)
I already know how to use formulas in Microsoft Excel 2007	5 point Likert scale (strongly disagree—strongly agree)	Pre-training Knowledge (new item)
What are PivotTable fields?	Columns from the source data The area where you pivot data The PivotTable report layout area.	Declarative Knowledge (Microsoft, 2008)
The first field you add to a PivotTable report that does not contain numbers will automatically be added in the _____ part of the report.	Column Labels Report filter Row Labels.	Declarative Knowledge (Microsoft, 2008)
The three main parts of the Ribbon are:	Tabs, groups, and commands The Microsoft Office Button, tabs, and access keys Menus, toolbars, and commands.	Declarative Knowledge (Microsoft, 2008)

Item	Response Scale	Construct (and Source)
Where should you look for items that used to be on the File menu?	On the Home tab On the Microsoft Office Button menu They're spread all over the Ribbon.	Declarative Knowledge (Microsoft, 2008)
Which of these are the two basic types of keyboard shortcut?	Navigation keys and Key Tips Shortcuts and Key Tips Combination keys that initiate a command and Key Tips.	Declarative Knowledge (Microsoft, 2008)
Which function key do you use to move between different areas of a program?	F4 F5 F6	Declarative Knowledge (Microsoft, 2008)
How do you get the badges showing the Key Tip letters to show?	Press CTRL+S Press the ALT key Press the CTRL key Press ALT, then S.	Declarative Knowledge (Microsoft, 2008)
What do you type into an empty cell to start a formula?	* (=	Declarative Knowledge (Microsoft, 2008)

Item	Response Scale	Construct (and Source)
A formula result is in cell C6. You wonder how you got the result. To see the formula, you:	Click in cell C6, and then press CTRL+SHIFT Click in cell C6, and then press F5 Click in cell C6.	Declarative Knowledge (Microsoft, 2008)
What is an absolute cell reference?	The cell reference automatically changes when the formula is copied down a column or across a row The cell reference is fixed The cell reference uses the A1 reference style.	Declarative Knowledge (Microsoft, 2008)
Which cell reference refers to a range of cells in column B, rows 3 through 6?	(B3:B6) (B3,B6)	Declarative Knowledge (Microsoft, 2008)
Which of these is an absolute reference?	B4:B12; A1	Declarative Knowledge (Microsoft, 2008)
If you copy the formula =C4*D9 from cell C4 to cell C5, what will the formula be in cell C5?	=C5*D9 =C4*D9 =C5*E10	Declarative Knowledge (Microsoft, 2008)

Item	Response Scale	Construct (and Source)
How would you print formulas?	Click the Microsoft Office Button and then click Print. Click Normal on the View tab at the top of the screen, click the Microsoft Office Button, and then click Print. Point to Formula Auditing on the Formulas tab, click Show Formulas, click the Microsoft Office Button, and then click Print.	Declarative Knowledge (Microsoft, 2008)
What does ##### mean?	The column is not wide enough to display the content. The cell reference is not valid. You have misspelled a function name or used a name that Excel doesn't recognize.	Declarative Knowledge (Microsoft, 2008)
What must you do to refresh a chart when you revise the worksheet data that the chart displays?	Press SHIFT+CTRL. Nothing. Press F6.	Declarative Knowledge (Microsoft, 2008)
You create a chart. But later on you don't see the Chart Tools. What do you do to get them back?	Create another chart. Click the Insert tab. Click inside the chart.	Declarative Knowledge (Microsoft, 2008)

Item	Response Scale	Construct (and Source)
You can't change the chart type after you create a chart.	True. False.	Declarative Knowledge (Microsoft, 2008)
To add an Excel chart to a PowerPoint presentation you:	Click the Data tab. Click the Insert tab. Copy the chart.	Declarative Knowledge (Microsoft, 2008)

Appendix A.8.

Supplemental Measures

Item	Response Scale	Construct (and Source)
The agent technology used in this training was easy to use	5-point Likert scale; *strongly disagree--strongly agree*	Satisfaction with Technology (adapted from Brown, 2005)
The agent technology used in this training allowed for easy review	5-point Likert scale; *strongly disagree--strongly agree*	Satisfaction with Technology (adapted from Brown, 2005)
I am satisfied with the agent technology used in this training	5-point Likert scale; *strongly disagree--strongly agree*	Satisfaction with Technology (adapted from Brown, 2005)
The agent was… attractive—unattractive	9 point bipolar rating scale	Agent Reactions (adapted from Warner & Sugarman, 1986)
The agent was… cheerful—depressed	9 point bipolar rating scale	Agent Reactions (adapted from Warner & Sugarman, 1986)
The agent was… friendly—unfriendly	9 point bipolar rating scale	Agent Reactions (adapted from Warner & Sugarman, 1986)
The agent was… warm—cool	9 point bipolar rating scale	Agent Reactions (adapted from Warner & Sugarman, 1986)
The agent was… knowledgeable—ignorant	9 point bipolar rating scale	Agent Reactions (adapted from Warner & Sugarman, 1986)
The agent was… competent—incompetent	9 point bipolar rating scale	Agent Reactions (adapted from Warner & Sugarman, 1986)
The agent was… responsible—irresponsible	9 point bipolar rating scale	Agent Reactions (adapted from Warner & Sugarman, 1986)

Item	Response Scale	Construct (and Source)
The agent was… intelligent—unintelligent	9 point bipolar rating scale	Agent Reactions (adapted from Warner & Sugarman, 1986)
The agent was… sensible—foolish	9 point bipolar rating scale	Agent Reactions (adapted from Warner & Sugarman, 1986)
The agent was… trustworthy—dishonest	9 point bipolar rating scale	Agent Reactions (adapted from Warner & Sugarman, 1986)
The agent was… credible—not credible	9 point bipolar rating scale	Agent Reactions (adapted from Warner & Sugarman, 1986)
The agent was… human-like—computer-like	9 point bipolar rating scale	Agent Reactions (adapted from Warner & Sugarman, 1986)
Would you enjoy working with this agent again?	5 point Likert scale; *not at all—very much*	Affective Reactions to Agent (Isbister & Nass, 2000)
How much did you like this agent?	5 point Likert scale; *not at all—very much*	Affective Reactions to Agent (Isbister & Nass, 2000)
How much did the agent improve your test score?	5 point Likert scale; *not at all—very much*	Utility Reactions to Agent (Isbister & Nass, 2000)
How much did you learn from interacting with the agent?	5 point Likert scale; *not at all—very much*	Utility Reactions to Agent (Isbister & Nass, 2000)
How helpful was the agent?	5 point Likert scale; *not at all—very much*	Utility Reactions to Agent (Isbister & Nass, 2000)