The Split-Persona Effect with Pedagogical Agents[1]

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Abstract

This experimental study examined the question as to whether it is more effective to have one pedagogical agent (Mentor) with combined expertise and motivational support or two separate agents – one with expertise (Expert) and one with motivational support (Motivator). It was found that having two separate pedagogical agents representing the two roles had a significantly more positive impact on both learning and the perceived value of the agents. This provides preliminary evidence for a pedagogical agent *split-persona effect*, suggesting that two separate agents representing different functional roles may be preferable to one agent representing both of the roles.

1 Introduction

The use of pedagogical agents is a relatively new phenomenon within the last 10 years or so, and many issues are currently in debate as far as what characteristics make them useful in terms of learning. One characteristic in particular for which little is known is regarding the value of presenting more than one pedagogical agent simultaneously to the learner. While the idea of representing multiple instructional roles through computer-based media has been implemented in other research, there have been limited controlled studies.

For example, the ETOILE system for teaching educational psychology principles (Dillenbourg, Mendelsohn, & Schneider, 1994) incorporated five agents, labeled after the teaching styles they implement: Skinner, Bloom, Vygotsky, Piaget, and Papert. The ETOILE system was not designed for the purpose of instructional research, but rather to conceptualize the underlying engineering principles for the multiple agents; consequently, there is no empirical evidence regarding its instructional impact. Similarly, the Thinker Tools SCI-WISE system (White, Shimoda, & Frederiksen, 2000) incorporates a whole community of agents that give strategic advice and guide middle school students in the process of scientific inquiry. The agents each have particular areas of expertise, with general-purpose agents such as Ingrid the Inventor, or task-specific agents such as Quincy the Questioner or Helena the Hypothesizer. White and colleagues (2000) argue that metacognitive processes are most easily understood and observed in a multi-agent system like SCI-WISE. However, no formal evaluation has been reported.

The most controlled study with multiple agents was conducted by Baylor (2002), where she experimentally examined the effect of 0-2 pedagogical agents representing instructivist and constructivist perspectives on instructional planning on learning and motivation. While she did not find that the presence of two agents was statistically more valuable for learning, there was clearly an impact of the two agents in promoting metacognitive awareness. In a different study investigating the effects of pedagogical agent feedback, Baylor and Chang (2002) found that the presence of two agents was preferable to one agent when the system provided non-adaptive (as compared to adaptive) and just-in-time (as compared to summative) feedback.

In particular, there are several characteristics that could be afforded through the presence of multiple agents: interaction, control, and choice. The presence of multiple agents can provide different perspectives from which to view the learning situation, and thus provide new opportunities for interaction. Moreno and colleagues (2001) found that interaction is a social agency criterion that must be present in order to facilitate recall, transfer, motivation, interest and persistence. To further substantiate the value of interactivity, White and colleagues (2000) found that the ability to access multiple agents facilitated the development of inquiry within their SCI-WISE pedagogical agent learning environment. In terms of the importance of control, Norman (1997) suggests that meeting such human needs as their ability to control their learning environment is essential. In fact, Locke & Latham (1991) state that one of the characteristics of goals that motivate action is learner-initiated direction. Along this line, Corno (1995) states that learner self-efficacy is built by providing the learner with choice.

Overall, Hietala and Niemirepo (1998) suggest that the same social factors that occur in learning communities with human beings are also influential in a learning community consisting of multiple artificial teaching and learning agents. They refer to this as a need for pedagogical multiplicity of teachers, suggesting that the many levels and complexities of the learning process might be alleviated by providing alternatives to the learner via an "extended family of intelligent agents." Building upon

[1] This paper is adapted from "The Pedagogical Agent Split-Persona Effect: When Two Agents are Better than One," (Baylor & Ebbers) in the Proceedings of ED-MEDIA, Honululu, Hawaii, 2003.

researchers' suggestions for agents to represent different "roles" such as characters in a play (Laurel, 1997) or social roles (Prendinger & Ishizuka, 2001), in this study the implementation of the agent roles of Expert and Motivator are examined. Specifically, the primary question that was examined was as follows: Is it more effective for learning and motivation to have one agent with *combined* expertise and motivational support (Mentor) or two separate agents – one with expertise (Expert) and one with motivational support (Motivator)?

2 Methods

2.1 Agent implementations

To compare the effects of one pedagogical agent (Mentor) embodying multiple roles (Expert + Motivator) to two separate agents, there were two experimental conditions:

1) Motivator + Expert condition: This implementation had the simultaneous presence of two distinctly different agents: the Motivator, and the Expert, as shown below in Figure 1.

The *Motivator* consisted of an agent named "Mike" with a friendly and energetic voice and youthful appearance (in line with the target population), with expressive animation. The *Expert* consisted of an agent named "Dr. Erickson" with a dry and straight-forward voice with little inflection, older appearance, little animation; informative and directive.

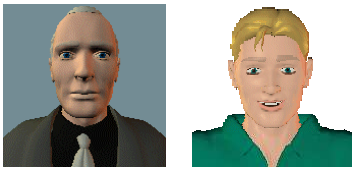

Figure 1. 2-agent condition: Expert + Motivator

2) Mentor condition: This condition had only one agent present – the Mentor – as shown in Figure 2, who embodied the roles of *both* Expert and Motivator.

The *Mentor* consisted of an agent named "Rick" with a friendly and calming voice, several years older than motivational agent, intelligent and informative, combining the Motivator agent qualities with the Expert agent information. His script was a combination of the Motivator and Expert scripts, so he was literally providing identical information than the two of them together, but embodied in just one agent.

Figure 2. 1-agent condition: Mentor

The operationalization of all three agent roles were validated as effective through two separate samples of participants (See (Baylor & Kim, 2003)).

2.2 Procedure

The participants included 48 undergraduates (17% male and 83% female) in an introduction to educational technology course. The average age of the participants was 20.32 (SD=3.77). They were randomly assigned to one of 2 conditions (Motivator+Expert, or Mentor) by the MIMIC agent-based research system, focused on teaching pre-service teachers instructional planning. MIMIC is centered around a case study of a 13-year old girl trying to learn the economic concepts of supply and demand. The participants were able to move among instructional planning phases (Case Study, Blueprints, Plan, Assessment) by clicking navigation buttons. When the participant entered each phase, the agent providing instructional information about the phase, and the participant could request additional information from the agent on his/her own initiative at any time. Once the participant completed the four phases, s/he answered questions in the areas of learning (recall, transfer of learning to develop a new instructional plan, and ease of learning) and motivation (self-efficacy toward instructional planning, satisfaction on performance, disposition toward instructional planning). The entire procedure took approximately 90 minutes.

2.3 Instrumentation

Instruments were developed to assess learning and motivational outcomes.

Learning

The dependent variable of learning was measured in terms of recall, transfer, and ease of learning. To assess *recall*, participants were asked to 'List all of the information that you can recall from using the program. List it in the order that you recall it. List as much information as possible." Each recall answer was decomposed into idea units (a procedure implemented by (Mayer & Gallini, 1990)). Credit (one point) was given for each idea in the student's answer that conveys the same meaning as an idea unit from the program. Incomplete ideas were acceptable. Three researchers coded a sample of the data until a criterion of r>.90 was reached to establish inter-rater reliability. Once there was agreement in the coding methods, one researcher performed the coding.

To assess *transfer*, participants were provided with the following question:

> Applying what you've learned, develop an instructional plan for the following scenario: Imagine that you are a sixth grade teacher of a mathematics class. Your principal informs you that a member of the president's advisory committee will be visiting next week and wants to see an example of your instructional about multiple of fractions.

Each instructional plan was scored according to a scale (where 1=poor and 5=excellent) that evaluated the overall plan in terms of how well the participant applied his/her knowledge of instructional planning to this particular situation. Three researchers met and together discussed what characterized a score of 1 through 5 while evaluating sample plans. Disagreements were resolved through discussion. Following that, each researcher independently scored 10 instructional plans. Inter-rater reliability be-

tween the two researchers was established at $r > .90$ for the ten instructional plans. One of the researchers then scored the remainder of the instructional plans using the same scale. In scoring each instructional plan, the researchers were blind as to participants' conditions.

Additionally, participants evaluated the overall program as "*easy to learn from*," on a 1-5 Likert scale.

Motivation

To assess motivation, questions were asked regarding self-efficacy, disposition, and satisfaction. A single item was used to measure students' *self-efficacy* based on Bandura and Schunk's (1981) guidelines for specificity, given that self-efficacy is the degree to which one feels capable of performing a particular task at certain designated levels (Bandura, 1986). All participants were asked, "How sure are you that you can write a lesson plan?" on a scale from 1 being not sure to 9 being very sure. The participants were asked how they are sure that they can develop a lesson plan when they finished the MIMIC environment.

To assess *disposition* regarding instructional planning, all participants were asked to write two adjectives to "Describe what you think about instructional planning." This method was employed to obtain the participants' personal affect regarding instructional planning as opposed to the response set that could bias them to choose more favorable adjectives if presented in a list. These adjectives were coded according to three levels: as -1 if both were negative, as 0 if 1 was negative and the other positive, and as +1 if both were positive. Two raters coded the items independently and interrater reliability was established at .96. There were only two disagreements about two sets of adjectives, which were resolved through discussion. Two adjective pairs were discarded because they could not be classified. The concurrent validity of this measure was supported in Kitsantas and Baylor (2001) by a significant positive correlation between initial disposition and initial self-efficacy scores. Prior research has shown that self-efficacious students generally have positive affect (Bandura, 1986).

To assess *satisfaction* regarding performance, following the development of each instructional plan, participants were asked to rate their satisfaction with their performance on the lesson plan on a scale of 1-5 where 1=Not at all satisfied and 5=Extremely satisfied.

2.4 Data analysis

The primary data analyses consisted of two one-way MANOVAs to compare the two conditions (1-agent versus 2-agents) on learning (transfer, recall) and motivation (self-efficacy, satisfaction, disposition). Additionally, a *t* test was conducted between the two conditions to compare ease of learning from the agents.

2.5 Results

Learning

Learning was assessed through a one-factor MANOVA, with transfer and recall as the dependent measures, and with condition (1-agent, 2-agents) as the between-subject factor. The MANOVA indicated that there was an overall positive effect of the 2-agent condition on learning, Wilk's Lambda = .83, $F(2, 45) = 4.54$, $p=.01$. Follow-up univariate analyses (ANOVA) indicated that significant differences occurred only for recall, $F(1,46)=5.98$, $p=.01$, where $M=4.57$ versus $M=2.95$.

An independent-group t test was conducted to evaluate whether the overall program was "easy to learn from," on a 1-5 Likert scale. It was found that those in the 2-agent condition found MIMIC to be significantly more easy to learn from than those in the 1-agent condition, $t(74.91)=2.87$, $M=3.89$ vs. $M=3.34$.

Motivation:

Motivation was analyzed through a one-factor MANOVA, with self-efficacy, satisfaction, and disposition as the dependent measures, and with condition (1-agent, 2-agents) as the between-subject factor. The MANOVA indicated that there was no significant overall effect of condition on motivation, Wilk's Lambda = .97, $F(2, 45) = .75$, $p>.4$.

3 Discussion

These results provide preliminary support for the positive impact of two agents in facilitating learning (particularly recall). This raises an interesting issue regarding agent embodiment: Why is it better to separate agent roles rather than combine them?

While the need for a pedagogical agent(s) to provide *both* motivation and information (rather than just one or the other) is clear, it is not intuitively obvious why having these functions present in *two separate agents* is desirable. Here, we found that the synergy that was present with two agents representing the separate roles led to a significant increase in learning; further, the agents were perceived as significantly easier to learn from. This *split persona effect* indicates that figuratively "splitting" an agent's persona by functionality into two separate agents may lead to greater learning.

From a cognitive load standpoint, perhaps it is easier for the learner to attribute certain types of comments (e.g., informational or motivational) to a particular agent (e.g., Expert or Motivator) rather than evaluating these comments together as part of one agent (e.g., Mentor). In this way, it may be easier for learners to compartmentalize the information, given that it is already pre-organized for them. In other words, participants in the one-agent condition (Mentor) had to take time to figuratively "tease out" what they needed to know (e.g., the agent's expertise), whereas those in the two-agent condition clearly understood each agent's role and made use of them as they desired. By designing a clear delineation of roles in the two-agent condition, learners' cognitive load requirements were reduced, deriving a more efficient learning situation. In support of this explanation, those in the two-agent condition reported that the program was significantly easier to learn from than those in the one-agent condition.

We also tentatively conclude from our findings that choice, control, and interactivity via the instantiation of multiple pedagogical agents may be important for facilitating learning. The better performance by those in the two-agent condition may be due to the increased collaborative interactivity that required the learner to exercise greater agency (Bandura, 2000) in choosing which agent would be more useful. Given that the learner had greater

control over his/her environment in the two-agent condition, s/he could determine which agent and which associated "role" to use when. However, based on this argument, it would have been expected that the two-agent condition would have led to increased learner motivation, particularly in terms of self-efficacy, yet this was not found. Consequently, more follow-up work needs to be conducted to tease out why this was the case.

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