

# The Pedagogical Agent Split-Persona Effect: When Two Agents are Better than One

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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.

## Introduction

The use of pedagogical agents is a relatively new phenomenon within the last 10 years or so, and many issues are unclear in terms of 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 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)?

## Methods

In order to compare the effects of one pedagogical agent (Mentor) embodying multiple roles (Expert, Motivator) to two separate agents (Expert + Motivator), two experimental conditions were developed: 1) Two-agent condition (Expert + Motivator); and 2) One-agent condition (Mentor).

### Two-agent Condition : Expert + Motivator

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



**Figure 1: Two-agent condition: Expert + Motivator**

The Expert consisted of an agent named "Dr. Erickson" with a dry and straight-forward voice with little inflection, older appearance, limited animation; with an informative and directive approach. 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 operationalization of the Expert and Motivator agent roles were validated to be effective through two separate samples of participants (see Baylor & Kim, 2003).

### One-agent Condition: Mentor

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



**Figure 2: One-agent condition: Mentor**

The Mentor consisted of an agent named "Rick" with a friendly and calming voice, intelligent and informative while expressive, 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 as the two of them together, but embodied in just one agent. The operationalization of the Mentor agent role was validated to be effective through two separate samples of participants (see Baylor & Kim, 2003).

## 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 the two conditions (One-agent or Two-agents) by the MIMIC agent-based research system, focused on teaching pre-service teachers instructional planning. MIMIC is designed 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) and motivation (self-efficacy toward instructional planning, satisfaction on performance, disposition toward instructional planning). The entire procedure took approximately 90 minutes.

## Measures

### *Learning*

Learning was measured in terms of recall and transfer. 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. 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 developed a new instructional plan for a different scenario involving teaching the multiplication of fractions to 6<sup>th</sup> graders. 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 between 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 which tool was used by the participant.

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

### *Motivation*

To assess motivation, questions were asked in three areas: 1) self-efficacy toward instructional planning, 2) disposition toward instructional planning, and 3) satisfaction regarding instructional planning performance. For details regarding these measures, which were based on principles as derived by Bandura (1986), see (Kitsantas & Baylor, 2001).

## Results

Learning was analyzed through a one-factor MANOVA, with transfer and recall as the dependent measures, and with condition (one-agent, two-agents) as the between-subject factor. The MANOVA indicated that there was an overall positive effect of the two-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  $M = 2.95$ . Regarding *ease of learning* from the program, an independent-group  $t$  test indicated that those in the two-agent condition found MIMIC to be significantly more easy to learn from than those in the one-agent condition,  $t(74.91) = 2.87$ ,  $M = 3.89$  vs.  $M = 3.34$ .

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

## 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.

## References

- Bandura, A. (1986). *Social foundations of thought and action: A social-cognitive theory*. Englewood Cliffs, NJ: Prentice Hall.
- Bandura, A. (Ed.). (2000). *Self-Efficacy: The Foundation of Agency*. Mahwah, NJ: Lawrence Erlbaum Associates, Inc.
- Baylor, A. L. (2002). Expanding preservice teachers' metacognitive awareness of instructional planning through pedagogical agents. *Educational Technology Research & Development, 50*(2), 5-22.
- Baylor, A. L., & Chang, S. (2002). *Pedagogical agents as scaffolds: The role of feedback timing, number of agents, and adaptive feedback*. Paper presented at the International Conference of the Learning Sciences, Seattle, WA.
- Baylor, A. L., & Kim, Y. (2003). *Validating Pedagogical Agent Roles: Expert, Motivator, and Mentor*. Paper presented at the ED-MEDIA, Honolulu, Hawaii.
- Corno, L. (1995). Working Toward Foresight and Follow-Through. *Mid-Western Educational Researcher, 8*(1), 2-11.
- Dillenbourg, P., Mendelsohn, P., & Schneider, D. (1994). The distribution of pedagogical roles in a multiagent learning environment. In R. Lewis & P. Mendelsohn (Eds.), *Lessons from learning* (pp. 199-216): Elsevier.
- Hietala, P., & Niemirepo, T. (1998). *Multiple artificial teachers: how do learners cope with a multi-agent learning environment?* Paper presented at the Workshop Proceedings on Current Trends and Applications of Artificial Intelligence in Education at The Fourth World Congress on Expert Systems, Mexico City, Mexico.
- Kitsantas, A., & Baylor, A. L. (2001). The Impact of the IPSRT (Instructional Planning Self-Reflective Tool) on Preservice Teachers' Performance, Disposition, and Self-Efficacy Beliefs Regarding Systematic Instructional Planning. *Educational Technology Research & Development, 49*(4), 101-110.
- Laurel, B. (1997). Interface agents: Metaphors with character. In J. M. Bradshaw (Ed.), *Software Agents* (pp. 67-78). Menlo Park, CA: MIT Press.
- Locke, E. A., & Latham, G. P. (1991). Self-Regulation Through Goal Setting. *Organizational Behavior and Human Decision Processes, 50*, 212-247.
- Moreno, R., Mayer, R. E., Spires, H. A., & Lester, J. C. (2001). The case for social agency in computer-based teaching: do students learn more deeply when they interact with animated pedagogical agents? *Cognition and Instruction, 19*(2), 177-213.
- Norman, D. A. (1997). How might people interact with agents. In J. M. Bradshaw (Ed.), *Software Agents* (pp. 49-56). Menlo Park, CA: MIT Press.
- Prendinger, H., & Ishizuka, M. (2001). *Social role awareness in animated agents*. Paper presented at the Agents 2001, Montreal, Canada.
- White, B. Y., Shimoda, T. A., & Frederiksen, J. R. (2000). Facilitating students' inquiry learning and metacognitive development through modifiable software advisers. In S. P. Lajoie (Ed.), *Computers as Cognitive Tools Vol 2: No More Walls* (pp. 97-132). Mahwah, NJ: Lawrence Earlbaum.

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