Evidence that Multiple Agents Facilitate Greater Learning

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Abstract. This experimental study examined the question as to whether it is more effective to have one pedagogical agent 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 learning.

Introduction

Many issues are currently in debate regarding what characteristics make pedagogical agents useful for learning. In particular, little is known is regarding the value of presenting *multiple agents simultaneously* to the learner. While agent-based learning environments have explored the potential of multiple pedagogical agents (e.g., [1]), limited controlled studies have been conducted (e.g., [2, 3]). Building upon researchers' suggestions for agents to represent different "roles" such as characters in a play [4] or social roles [5], this experimental study examines whether it is more effective for learning 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).

1. Methods

In order to examine the effects of one pedagogical agent embodying multiple roles (Expert + Motivator) as compared to two separate agents, two experimental conditions were developed: the two-agent condition and the one-agent condition as shown below in Figures 1 and 2.

Figure 1. Two-agent condition: Expert + Motivator

Figure 2. One-agent condition: Mentor

The operationalization of each agent -- Motivator, Expert, and Mentor – was validated experimentally through two separate samples of the target population (See [6] for details).

The *two-agent condition* had the simultaneous presence of two distinctly different agents: the Motivator, and the Expert, as shown in Figure 1. The Motivator was 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 Motivator was validated to be effective through two separate samples of participants (See [6]). The Expert was an agent named “Dr. Erickson” with a dry and straight-forward voice with little inflection, older appearance, little animation; informative and directive.

The *one-agent condition* had only the Mentor agent present, as shown in Figure 2, who embodied the roles of both the 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.

1.2 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. MIMIC is designed to teach instructional planning to pre-service teachers and is focused on 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) within MIMIC. When the participant entered each phase, the agent(s) provided initial comments, and the participant could request additional information from the agent at any time. Once the participant completed the four phases, s/he answered questions to assess learning (recall, transfer of learning, and ease of learning). The entire procedure took approximately 90 minutes.

Learning was measured in terms of recall and transfer. One additional Likert-scale question assessed participants’ 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 [7]). 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 using 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 the scenario. Three researchers met and together discussed what characterized a score of 1 through 5 while evaluating sample plans, resolving disagreements through discussion. Next, each researcher independently scored 10 instructional plans. Inter-rater reliability between the two researchers was established at $r > .90$ for the ten plans. One researcher then scored the remainder of the instructional plans using the same scale. In scoring each instructional plan, researchers were blind as to which tool was used by the participant.

2. 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 $M=2.95$.

An independent-group t test to evaluate ease of learning from the program indicated that 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. $M=3.34$.

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? 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.

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