# TOWARDS BUILDING PEDAGOGICAL AGENTS BASED ON EXPERIMENTS

## *A Preliminary Result*

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Abstract: Pedagogical agents are computer generated characters that supports learning. Pedagogical agents gained increasing interest in past decades, but research on pedagogical agents have produced mixed results on learning outcomes. We plan to adopt trial-and-error approach, based on knowledge gathered from field of cognitive science. While the main purpose of this paper is to discuss future direction of our work, it describes an experiment carried out as a preliminary step. Five participants were presented with word learning task, with and without physical image of pedagogical agent. The result suggests that pedagogical agent itself does not harm learning, even when it is irrelevant to learning material.

## 1 INTRODUCTION

Pedagogical agents are characters presented on computer screen that promote user's learning experience. Pedagogical agents are required to be presented as physical image, but other functions such as movement, voice are considered supplemental.

Although research concerning pedagogical agents has started promisingly in early 1990s, since then it has produced mixed results, often producing no or little educational outcome. Some authors argue pedagogical agents have little direct impact on learning (Baylor, 2011), but the conditions of use of pedagogical agents (i.e. education contents, pedagogy) and its design varies greatly among studies, thus whether pedagogical agents can or cannot produce positive educational outcome remains unanswered (Heidig and Clarebout, 2011).

Research on pedagogical agents is highly complex, requiring convergence of several fields of studies, such as computer science, cognitive science, and pedagogy. Among these, pedagogy is arguably of utmost importance when designing pedagogical agent, as it defines the goal of the system. In present research, we follow natural pedagogy proposed by Csibra and Gergely (2009). Natural pedagogy theory claims that human communication is specifically adapted to allow the transmission of generic knowledge, and ability to receive such signals is naturally given. Our goal is to assess subtle movements triggering natural pedagogy and implement them in pedagogical agents, hence fostering effective and fast knowledge transfer. We also follow teaching-as-transfer view over teaching-as-communication view, as the latter has been rejected both empirically and theoretically (Kirschner et al., 2006), and as we believe knowledge transfer is necessary for any other educational methods.

The purpose of this paper is to describe an experiment carried out as preliminary step of our research, and to discuss future work.

## 2 EXPERIMENT DESIGN

Before working on ways to design effective pedagogical agents, we felt the need to confirm that fundamental elements of pedagogical agents do not hinder user's learning. Since irrelevant adjunct information is said to hurt learning (Harp and Mayer, 1998), elements of pedagogical agents such as physical image and movement may actually act as interference. Although numerous studies have already shown pedagogical agents do not cause such damage (Moreno et al., 2001, Moundridou and Virvou, 2002), their interaction model may have


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canceled out the original effect. To answer this question, we created an agent that has minimal interaction function and is irrelevant to learning material. A simple foreign language word retention task was used. The participants were presented with read out words in their native language (Japanese) and foreign language (Korean), and were asked to remember the latter. A photo was presented for each word, to clarify the meaning.

The design included one within-subject variables: pedagogical agent's visibility. During learning phase, two conditions were provided: with physical image of pedagogical agent (Ag condition), and without physical image of pedagogical agent (no-Ag condition). Each participant learned under both conditions, and was tested immediately.

# 3 METHOD

## 3.1 Pedagogical Agent

While limiting its functions, we aimed to design agent's appearance to be humanlike, to open up the potential to equip it with subtle human behaviours. The agent was developed as three-dimensional character using Face Robot©, and photorealistic textures were used to enhance graphical quality (see figure 1). Although the agent is capable of behaviours such as blinking, eye movement, and complex facial expression, only lip movement was applied for this experiment. The agent's lip movement was synchronized to pre-recorded voice using viseme method, and was done semi-automatically by Face Robot©.

Figure 1: A close-up view of the pedagogical agent.

## 3.4 Participants

At current stage, we were able to gather 5 college students (3 females). Every participant was native Japanese speakers, and had minimal pre-experience with Korean, the foreign language used in this experiment.

## 3.5 Procedure

After arriving at the laboratory, participants were told to seat in front of a computer screen, and were instructed to memorize Korean words. They were told there would be a test afterwards. After learning phase, participants were tested after 1-min break. The experiment was done in soundproof environment. Whole process took around ten minutes.

### 3.5.1 Learning Phase

For learning phase, Ag condition and no-Ag condition were provided (see figure2). After learning under one condition, each participant learned under another condition without taking any break. To assess order effect on which condition comes first, order of conditions was counter balanced. Fifteen words were presented for each condition, total of thirty words. A photo was displayed, and a word describing the photo was presented by voice output, first Japanese then Korean. Each word was read out twice. Every word was a noun, consisting of less than five syllables (for both Japanese and Korean). Words were presented in random order.

Figure 2: The participants learned from two conditions. In Ag condition (left) pedagogical agent was visible, and in no-Ag condition (right) it was not.

### 3.5.2 Test Phase

After 1-min break, participants were tested whether they remembered the words. Four photos were presented and word describing one of them was read out twice, and participants had to pick the right answer (see figure3). All thirty words were tested.

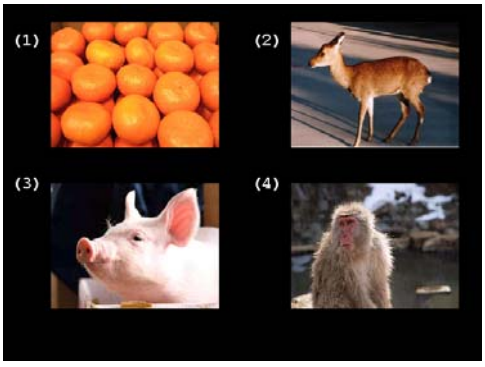


Figure 3: A sample of computer screen during test phase.

### 3.5.3 Voice

Voice was pre-recorded by native Korean speaker, who also speaks near-perfect Japanese. Text-to-speech was not used for several reasons:

- Does not support multiple language in same voice;
- Lacks modulation, which may be crucial for natural pedagogy
- Human voice have been reported not only to be preferable over synthesized voice, but to have advantage on learning outcomes(Atkinson et al., 2005)

## 4 RESULTS

Because the number of participants enrolled in the experiment was limited, the data were not analyzed statistically. However, the test scores (see Table 1) showed no significant difference between A and no-Ag condition. Four participants remembered words better when they were taught under Ag condition, and while one participant remembered less, the margin was minimal (one word). The order effect of conditions did not appear consistently, on either direction. All participants scored above chance level, which was 25%.

Table 1: Number of errors of each participants (P1~P5).

| | ORDER OF CONDITIONS (FIRST) | | | | |
|---|---|---|---|---|---|
| | Ag | | no-Ag | | |
| | P1 | P2 | P3 | P4 | P5 |
| Total | 17 | 7 | 2 | 5 | 3 |
| no-Ag | 11 | 5 | 2 | 2 | 2 |
| Ag | 6 | 2 | 0 | 3 | 1 |

## 5 CONCLUSIONS AND FUTURE WORK

In this experiment, the physical image of pedagogical agent did not damage learning outcomes, even when it was irrelevant to learning material and lacked interaction. Although more experiment is required regarding participant group and more complex learning materials, one can carefully argue that pedagogical agent itself is not harmful to learning.

In future work, we plan on bracing pedagogical agent with more sophisticated behaviours that could trigger more smooth information transfer. Attention guiding system using eye movement, gesture and facial expression is being implanted, using technologies such as motion tracker, camera and eye-tracker, and we want to improve it to point where it could actually produce positive learning outcomes. We are also working on automatic voice modulation system, in belief that voice modulation plays great role during information transfer process.

We are planning to gather participants from much younger groups (i.e. preschoolers), to find the natural way in which human receives information. They can provide new and important insight, since they are not yet trained by traditional ways of learning, and they do not posses ability to overcome inefficiencies that may reside on our way of teaching, unlike adults.

As for learning materials, while adding more complexity, they will be carefully selected from subjects that learning outcomes could be tested numerically and presented clearly. We will also attempt to compare our system with other teaching methods, and identify the cause of gaps between. While this study focuses on efficient information transfer, we do not seek to bring older way of teaching back which was criticized of putting too much emphasis on memorizing and strong guidance. Instead, our ultimate goal is to make the transfer process as fast and not painful as possible to let more time to be spent on creative, meaningful learning.

Finally, we will be working with revision process in mind, which differs from previous attempts made by other groups. Experiments and updating policy will be based on extensive knowledge gathered from field of cognitive science.

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