Investigating Different Teaching Activities in Learning by Teaching a Virtual Character

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ABSTRACT

Learning by teaching, which makes students teach others, is a popular way to facilitate students' learning. This study investigates the learning effects of different teaching activities in a condition of learning by teaching a virtual agent. The investigated teaching activities include demonstration, tutoring, and combing demonstration and tutoring. An experiment was done and results were reported.

Keywords: learning by teaching, demonstration, tutoring

1: INTRODUCTION

Learning by teaching, which students provide instructions for someone, has drawn much attention. Briggs [1] regarded that the best way to learn is to teach others. Whiteman [2] pointed out ”to teach is to learn twice”. Several researches also show that learning by teaching can benefit students' learning [3, 4, 5]. One approach to employ learning by teaching is peer tutoring; that is a student teaches another student [6, 7]. In some cases, a student plays the role of a tutor to teach another student and then the students exchange their role so that students play the role of a tutor and a tutee in turns [8, 9, 10]. Providing a teachable virtual agent is another approach for students to engage in learning by teaching activities [11, 12, 13, 14, 15, 16]. The main advantage of replacing teaching another student by teaching a virtual agent is that the agent can be designed for fitting the student's individual situation and specific educational purpose [17].

Teaching activities in learning by teaching vary, such as studying and preparing for teaching [3], presenting knowledge [3, 11, 16], or monitoring and guiding the tutee's works [14, 15]. However, the effects of different teaching activities in learning by teaching were little explored and compared. Therefore, the research issue we want to investigate is: *Do the learning effects of different learning by teaching activities differ?* Most virtual agent systems for learning by teaching adopt two kinds of teaching activities: demonstration or tutoring. Some systems engage students in teaching a virtual agent by demonstrating some examples or knowledge [13, 16]. The demonstration enables students to practice and reflect their knowledge. Other systems enable students to teach by tutoring a virtual agent; that is, the students monitor, correct, and guide the virtual agent's knowledge or problem solving [14, 18, 15]. Although RTS [18] and PALs [19] systems engage students in practicing knowledge and tutoring by playing the role of a tutee and a tutor in turns, students practice and tutor in different problems. We try to let students learn by both demonstrating and tutoring in the same learning task or problem, thus apprenticeship, which involves demonstration and tutoring, is adopted as the teaching activity [20]. The student plays the role of a master and a virtual agent plays the role of an apprentice. The master demonstrates and models the learning task to the apprentice, then master tutor the master to do the learning task. This study aims to compare the learning effects of three teaching activities: demonstration, tutoring, and demonstration and tutoring.

2: METHOD

The participants were 75 college undergraduate students enrolled in a Computer Programming II course at the Yuan Ze University. The participants learned recursion concept about one hour in a previous Computer Programming I course. Participants received partial course credit for their participation.

2.1: MATERIALS

The text is to introduce the concept of recursion and to teach writing three recursive C programs to solve problems. These programs are three kinds of recursive programs. The first program includes a based case and a recursive call. The second program includes two based cases and a recursive call. The third program includes two based cases and two recursive calls. The questions of pretest are filling nine blank spaces of three recursive programs, which are the same as the text. Each program has three blank spaces for students to fill with. The assessment of the pretest is to access the students' ability to write the three programs in text. The posttest includes Retention Test and Transfer Test. The Retention Test assesses whether the students remember the text or not. The questions of Retention Test are as same as that of the pretest. The Transfer Test assesses whether the students apply the knowledge in the text to another similar problem [21]. The Transfer Test contains three recursive programs, which are similar recursive programs to that in text; that is, a program with a based case and a recursive call, a program with two based cases and a recursive call, and a two based cases and two recursive calls. The first program of Transfer Test has six blank spaces, the second has two blank ones, and the third has three blank ones.

2.2: PROCEDURE

Participants were divided into four groups: reading (control group, termed as Group R), demonstration (Group D), tutoring (Group T), and demonstration and tutoring (Group DT). At first, participants completed pretest. Then students of different groups are asked to engage in different computer lessons. The students of Group R read the text for 40 minutes (Figure 1). Students of Group D read the text for 15 minutes and demonstrated to write programs to solve the problems during 25 minutes. Students of Group T read the text for 15 minutes and tutored an agent to write programs during 25 minutes. Students of Group DT read the text for 15 minutes and then demonstrated and tutored an agent to write programs during 25 minutes. After learning activities, participants completed posttest.

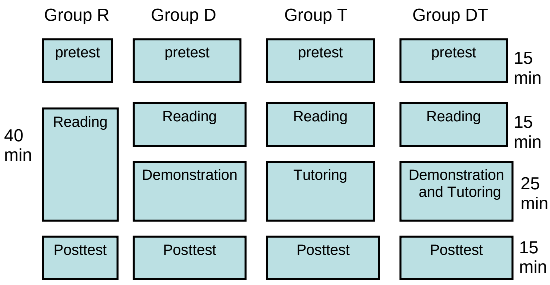

Figure 1. Grouping

2.3: LESSON CONDITIONS

A system, which contains three functions: reading, demonstration, and tutoring, is implemented and supports different computer lessons of four groups. When reading text, students can leap from one topic to another topic among basic recursive concept and three recursive programs to solve problems (Figure 2).

Figure 2. Interface of reading material

When demonstrating to solve a problem, students saw the problem, modified an incomplete program, and executed the program to see whether it solves the problem or not (Figure 3). If a student can not solve the problem successfully, a "Help" option in menu is provided for the student to read the text again for one minute.

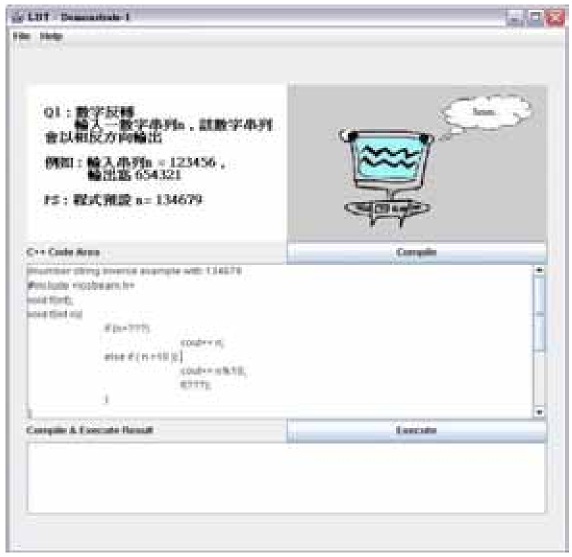

Figure 3. Interface of demonstration

When tutoring the agent to solve a problem, students saw the problem and the program written by the agent (Figure 4). The agent's program is designed to have some bugs and the agent will ask the student to check the program. The student must use the "Prompt" option to provide suggestion to the agent. The suggestion includes indicating the error in base condition, indicating the error in recursive call, or correcting the program directly. When the student indicated the agent's error, the agent will correct the program in the first and second problems, but will ask the student to correct the program in the third problem. If a student can not help the agent solve the problem successfully, a "Help" option in menu is provided for the student to read the text again for one minute.

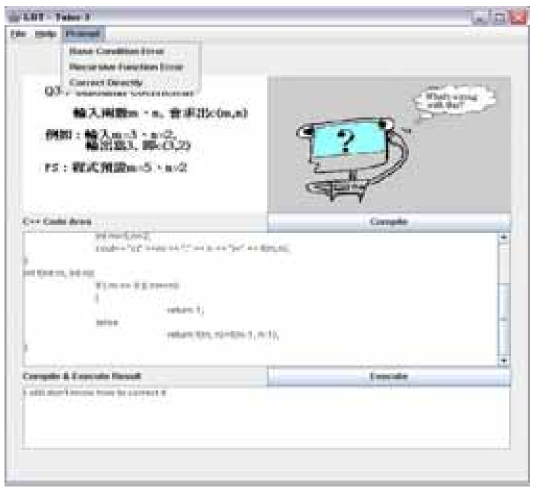

Figure 4. Interface of tutoring

3: ANALYSES AND RESULTS

This section presents the experimental results and analyses.

3.1: SCORING

Because the problems in pretest and posttest varied in their difficulties, weighted scores were used to more accurately measure competence. The weight of each blank space was calculated according to their difficulties by performance of the participants on each blank space. For example, the number of participants who did not answer each blank space was counted as fail number of the blank space. Then the weight of each blank space was calculated by dividing the fail number of the blank space by total fail number of all blank spaces. Table 1 lists the weight of each blank space in the Pretest, which was calculated by the data of all participants. The weights of Transfer Test were calculated by the data of Group R (Table 2).

Table 1. Weight of each blank space in the Pretest

Problem	#1			#2			#3		
Weight	8	9	6	9	11	22	13	11	11

Table 2. Weights in the Transfer Test

Problem	#4						#5		#6		
Weight	10	15	10	17	13	19	0	6	0	0	10

3.2: LEARNING EFFECTS

After scoring, the participants attaining more than 90 score in the Pretest were excluded because they almost master the text. One participant was excluded in the Tutoring group and two were excluded in the Reading group. The learning effects of four groups are listed in Table 3 and showed in Figure 5. Results of an ANOVA test on the data showed that there was no statistically significant difference among the learning performances of four groups although the students of Group DT seemed to perform better in Retention Test and the students of Group R seemed to perform better in Transfer Test.

Table 3. Results of participants scoring under 90 in the Pretest

	Group DT (n=20) mean (sd)	Group D (n=18)	Group T (n=18)	Group R (n=16)	*p*
Pretest	42.95 (491.2)	44.33 (599.1)	40.72 (444.9)	48.38 (623.4)	0.8068
Retention Test	96 (57.5)	92.94 (120.8)	93.67 (165.6)	88.75 (190.3)	0.3071
Transfer Test	48.9 (798.9)	40 (611.2)	43.22 (1000.3)	58.88 (744.1)	0.2344

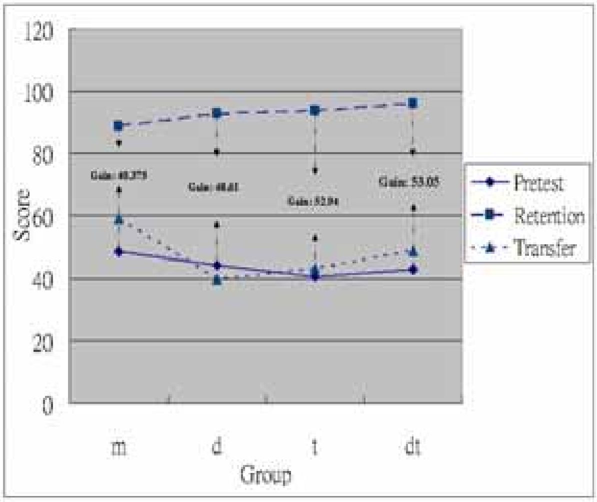

Figure 5. Results of participants scoring under 90 in the Pretest

While all means of pretest scores of four groups are higher than 40, many students know much about the text before learning. In order to examine the learning effects of those who did not know much about the text before learning, the learning effects of four groups were calculated again by excluding participants who attain more than 50 score in the pretest. Table 4 lists the results of ANOVA test on the data and Turkey's LSD to make pair wise comparisons. The students of Group DT and Group D performed better than that of Group R in Retention Test. The students of Group DT and Group R performed better than that of Group D and Group T in Transfer Test. In sum, the students of Group DT performed better both in Retention Test and Transfer Test for those students who did not know much about the text before learning (Figure 6). Noticeably, the students of Group R also performed better in Transfer Test for those students who did not know much about the text before learning.

Table 4. Results of participants scoring under 50 in the Pretest

	Group DT (n=14) mean (sd)	Group D (n=10)	Group T (n=10)	Group R (n=8)	*p*
Pretest	31.36 (165)	25.3 (160)	25.7 (201.5)	27.5 (157.1)	0.6484
Retention Test	95.86 [A] (53)	92.3 [B] (108.9)	88.6 (248.7)	80.25 (216.7)	0.0399
Transfer Test	51.64 [EF] (870.8)	32 (546.6)	25.8 (479.9)	56.75 [C D] (963.0)	0.0383

[A] Significantly greater than Group R, $p < 0.05$
[B] Significantly greater than Group R, $p < 0.05$
[C] Significantly greater than Group D, $p < 0.05$
[D] Significantly greater than Group T, $p < 0.05$
[E] Significantly greater than Group D, $p < 0.05$
[F] Significantly greater than Group T, $p < 0.05$

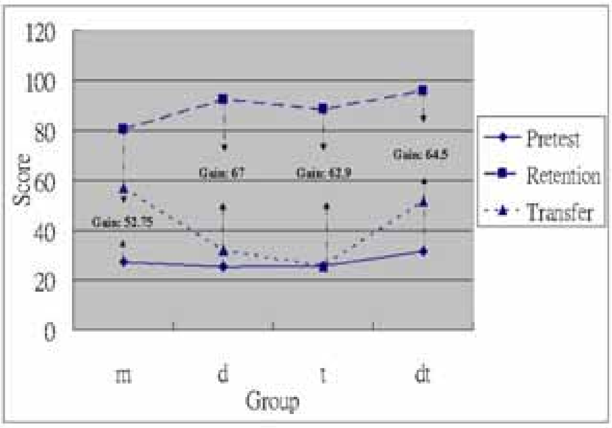

Figure 6. Results of participants scoring under 50 in the Pretest

4: CONCLUSION AND DISCUSSION

This study investigates the learning effects of different teaching activities in learning by teaching a virtual agent. The results showed that combing demonstration and tutoring as teaching activities make those students, who did not know much about the text before learning, have better learning performances both in retention and transfer.

However, this study has some limits, which might affect the results, and arouses more research questions. First, in this study, the students demonstrate by modifying incomplete program. The results might be different if the students demonstrate by writing the whole program. Similarly, the students tutor by correcting the agents' program. The virtual agent only asks tutor to point out the bugs or correct the bugs. Some strategies or scaffoldings may affect the tutors' learning effects, for an example, self-regulation strategies can make tutors perform better in learning by teaching [16]. It could also be different if the virtual agent acts in a different way. For instance, a research showed that the tutee's deeper questions make the tutor learn better [22]. Second, the text in this study contains writing recursive C programs to solve problems, which involve syntax, procedural skills, and problem solving skills. Adopting other texts, such as realizing complex relationships or inductions, might have different results. The research revealed that tutors seem to learn better in teaching mathematics than teaching reading [4]. Third, the assessments of learning performances are to test whether the students can fill out some blank spaces on programs to solve the same problems as the text and similar problems. Different or deeper assessments, such as preparation for future learning transfer test, might expose further learning effects. Fourth, the participants of this study are undergraduate students; however, many researches of learning by teaching investigate and apply to children. Fifth, this study was done during an environment of learning by teaching a virtual agent, so it needs more explorations whether do similar effects exist in learning by teaching a real student. Whether these factors affect the results is required to be more investigated.

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