The Effects of Peer Tutoring and Teachable Agent on Interest and Task Performance

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Abstract

This experiment was conducted to compare the effects of peer tutoring with an intelligent teachable agent (TA), the Korea university intelligent agent (KORI), on students' interest and task performance according to their level of self-efficacy. The results showed a significant interaction effect on interest between the peer tutoring/KORI and the level of self-efficacy. The high self-efficacious group had greater interest in peer tutoring than in KORI, whereas the low self-efficacious group had greater interest in KORI than in peer tutoring. Analysis of the task performance revealed that there was a main effect of peer tutoring/KORI and interaction effect on the task performance between peer tutoring/ KORI and the level of self-efficacy. The participants with high self-efficacy received high scores in both peer tutoring and KORI, whereas the participants with low self-efficacy gained higher scores in KORI than in peer tutoring.

Keywords: teachable agent, peer tutoring, interest, task performance

Introduction

Peer tutoring is an effective learning method based on the concept of learning by teaching. Previous studies have provided plenty of evidence that peer tutoring is an effective method of learning for both tutor and tutee (e.g., Kulik & Kulik, 1982). Ginsbug-Block and Fantuzzo (1997) reported that peer tutoring enhanced the tutee's academic achievement, social relationship, self-concept and motivation to learn, while simultaneously promoting the tutor's patience and ability for task performance, self-control, and motivation. Furthermore, peer tutoring increased the tutor's positive attitude toward the tutee and basic understanding of the subject areas (Cohen et al., 1982). Thus, peer-tutoring activities have been regarded as a meaningful learning method for improving cognitive ability and academic motivation for both tutor and tutee.

Despite these potential benefits, peer tutoring has some limitations in practical learning settings. In face-to-face peer tutoring, tutors can experience a cognitive burden because of the large amount of information they are required to remember for effective teaching, and thus lose confidence in tutoring. In addition, we can't completely rule out the possibility that tutees don't perfectly understand what tutors teach and even worse may learn misconceptions because due to the tutors' inexperience in teaching skills (Kim et al., 2003). Peer tutoring also has restrictions in space and time, while unnecessary interactions between tutor and tutee, which can interfere with the learning process, might occur with younger participants.

Various highly developed fields of information and technology are presently available. Accordingly, with the development of computers and communication technologies, students are growing up with technology. It is therefore desirable to effectively utilize such technologies in education. In fact, the traditional computer assisted learning (CAL) system has been utilized in educational settings for a long time. However, CAL systems such as the intelligent tutoring system (ITS) are based on passive learning activities in which the students are provided with learning materials and required to memorize them repeatedly via CAL. Thus, many researches have criticized the iterative and passive practice problems of CAL. In addition, traditional CAL does not reflect individual differences such as learner's cognitive ability and motivational aspects. Actually, the use of an identical interface, regardless of the individual differences, might be not only less effective in cognitive aspects of learning but also less interesting in terms of motivation.

To overcome the limitations of peer tutoring and CAL, Schwartz et al (2000) proposed the new concept of learning by teaching through an agent called the Teachable Agent (TA). TA is a computer program in which students teach the computer agent to enhance their motivation and cognitive ability based on the instructional method of 'learning by teaching'. That is, a computer-based system utilizing the benefits gained from the act of teaching has been developed to use TA as one of the ITS programs. In this TA, the agent provides student tutors with an active role and positive attitude toward the subject matter. Thus, learners are enabled to organize and acquire problem solving knowledge about various domains for instructing an intelligent agent (Biswas et al., 2001)

In this study, we developed a kind of TA, the KOREa university intelligent agent (KORI) (Kim et al., 2005a, 2005b), and investigated its effectiveness in comparison with peer tutoring on students' task performance and interest according to their level of self-efficacy.

Interface Design of the Teachable Agent (TA), KORI

KORI is a new TA developed to enhance the students' academic motivation and facilitate learning, and was applied in this study to students learning about the rock cycle. Similar to the typical TA, KORI consists of four independent modules: planning, teaching, testing and resource. Unlike previous TAs such as Betty, Milo and Orbo which were developed at AAA lab in Stanford university, KORI contains a narrative structure and various learning activities, which were designed to enhance learning motivation. As the story-like context of KORI (e.g., travel story) is presented, the student tutor perceives that the interaction with KORI is more like a game than boring instructions (Figure. 1).

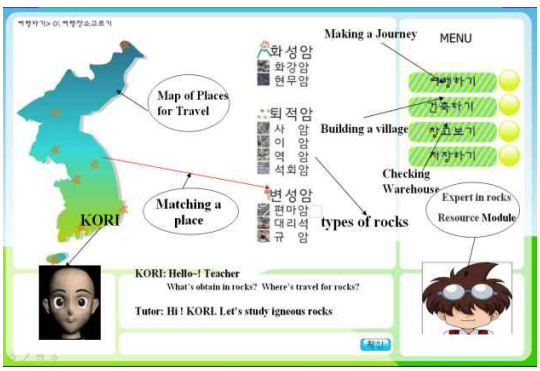

Figure 1: Basic Interface

Planning module. The planning module asks the students to write the teaching plan for three rocks and the rock cycle. There are four empty boxes to type their own teaching plan on the three kinds of rock and their transformation cycle. This module introduces the students to the role of a tutor, involves them more deeply in the teaching situation, and increases their responsibility. In this module, the students can make a teaching plan by themselves, which includes collecting and sorting the learning materials to teach from the learning resource, depending on the order of teaching certain materials, the amount of teaching time, the frequency of teaching, and the key points. Particularly, planning activities might improve the learners' metacognitive ability, which is the main skill for formulating and following through on plans (Figure. 2).

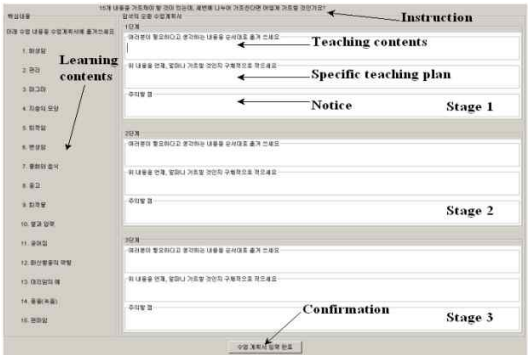

Figure 2: Lesson Plan to Teach KORI

Teaching module The teaching module consists of two units: concept teaching and relation teaching. In the former, the student can teach the true propositions to KORI and correct the false propositions in KORI's knowledge structure by using the teaching tools (Figure. 3). In the concept teaching activity of this study, the student teaches the basic concepts of three kinds of rock: igneous, sedimentary, and metamorphic. KORI is taught by inserting five correct propositions and removing five incorrect propositions among 15 given propositions. While teaching KORI, students can also use the resource module whenever they need information.

In relation teaching, as shown in the concept map interface of Fig. 4, the students can teach KORI by drawing the concept map by using the tool box. Like concept teaching, the students can also use the resource module while interacting with KORI.

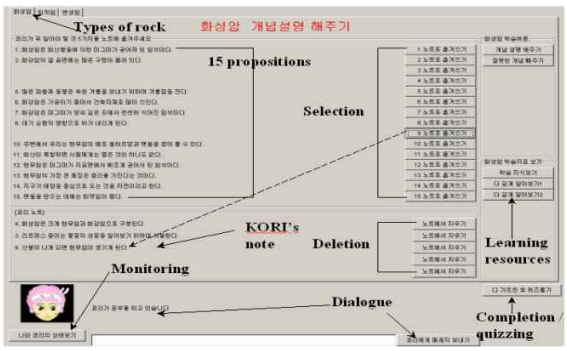

Figure 3: Rock's Concept Teaching

Testing Module: KORI's knowledge is evaluated in the testing module. KORI sets a quiz at the end of each teaching session that consists of 6 questions on the content KORI was taught. Although KORI appears to be taking the quiz, it is in fact evaluating the student tutor's level of knowledge and comprehension. Since KORI's answers on the quiz are based on the information taught by the student tutor, KORI's achievement level reflects the cognitive learning outcome of the student.

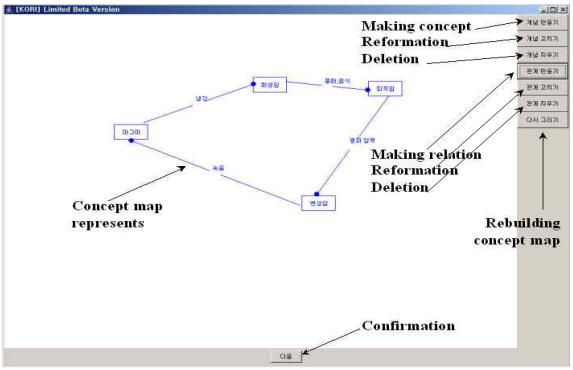

Figure 4: Relation Teaching

Resource Module The students can access this module by clicking the icons whenever they want to know more about rocks while teaching KORI. The resource is made of hypertext that links the basic concepts to concrete images and examples. There are two different levels of learning resource: basic and additional. The former is essential knowledge about rocks and the rock cycle for teaching KORI. The latter is practical knowledge about rocks and the rock cycle to satisfy student's curiosity in real life.

In order to develop an adaptive system in the new generation of ITS to enhance academic motivation and cognitive ability, individual differences were accounted for. Self-efficacy among individual differences related to motivation to learn is one of the main variables. Connell and Wellborn (1991) reported that many people have three fundamental needs, competence/self-efficacy, autonomy and relatedness, of which the first is the most critical factor in learning. Self-efficacy is individual's belief as being capable of producing desired outcomes and having the expectation of success (Bandura, 1997).

The main purpose of this experiment was to examine the effectiveness of the newly developed intelligent

TA, KORI, and to determine the best method to provide learners with KORI or peer tutoring in terms of improving interest and task performance. We therefore compared KORI with peer tutoring according to the level of self-efficacy.

Methods

Participants and Design

The sample consisted of 41 (22 male and 19 female) fifth graders who were randomly assigned to either peer tutoring or KORI. The independent variable, peer tutoring and KORI, was manipulated while interest and task performance were chosen as the dependent variables. The level of self-efficacy was an individual variable.

Materials and Measures

The basic learning material was an eight-page long text on the 'rock cycle' extracted from the 7th grade textbook. Since the 'rock cycle' is the content for seventh graders, the text of the 'rock cycle' was revised to be suitable for fifth graders.

A revised version of the scale of academic self-efficacy developed by Kim et al (2003) was used (Cronbach's α=.85). The questionnaire to measure interest comprised 9 items: 6 regarding the enjoyment and interest in the activity and content and 3 regarding the feeling of satisfaction and challenge. The reliability coefficient of interest in the questionnaire was .75. The test score for task performance was composed of 20 true-false questions on the 'rock cycle'.

Procedure

Before the experiment, all participants took a 30-minute lesson on the 'rock cycle' together to acquire the base knowledge in the domain. They then took a previous test on general science including the rock cycle.

The participants were randomly assigned to one of the two experimental conditions: peer tutoring and KORI. Next, the participants of each condition moved into a separated place and performed their own learning activity.

Participants in the peer tutoring condition were paired based on their previous science test score and were asked to teach each other by playing the role of either tutor or tutee. The experimenter assigned tutor and tutee roles for those with higher and lower science test scores, respectively, because previous studies have shown that students with less ability tend to have serious difficulty in peer tutoring (King, 1998). Both tutor and tutee believed that they were randomly assigned to the role although, in fact, their role was predetermined based on test score. Both tutor and tutee were given the same text and asked to read it for 10 minutes, after which the tutors were instructed to teach their tutees freely for at least 20 minutes.

In the KORI condition, each participant was asked to teach KORI individually and was informed of KORI's basic concept and method of use. Participants taught KORI for approximately 30minutes, using the concept teaching and map modules.

After finishing all of the learning activities in each condition, all participants were asked to complete the items for measuring self-efficacy, to rate their interest using a 5-point scale on their own learning activity and learning material, and were given the test for checking the ability of the task performance.

Results

We conducted two-way (analysis of covariance) ANCOVA to test the main effect and interaction effect on interest and task performance, using the participants' previous test scores as a covariate. The means and standard deviation of interest are shown in Table 1 and Fig. 5.

Interest

There was a significant, two-way interaction effect on interest between conditions such as peer-tutoring and KORI and the level of self-efficacy [$F_{(1,\ 35)}$=9.79, p<.01]. To explicate the exact interaction effect, the simple main effect (SME) was analyzed. Participants with high self-efficacy revealed higher interest in the peer tutoring condition than in the KORI condition [$t_{(18)}$=2.204, p<.05], whereas participants with low self-efficacy were more interested in the KORI condition than in the peer tutoring condition [$t_{(19)}$=-2.219, p<.05].

Table 1. Means and Standard Deviation for Interest

Conditions	Self-efficacy	MEAN	SD	N
Peer tutoring (N=20)	High	4.23	.31	10
	Low	3.73	.40	10
Teachable agent(TA),KORI (N=21)	High	3.82	.43	10
	Low	4.34	.38	11

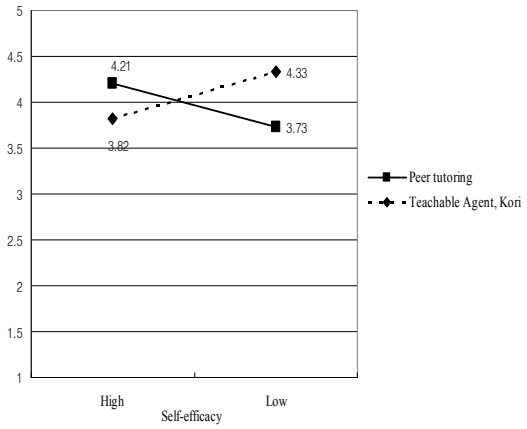

Figure 5: Interest rating by peer tutoring/KORI and self-efficacy

Task Performance

There was a significant main effect of conditions and interaction effect of conditions such as peer-tutoring/KORI and the level of self-efficacy [$F_{(1,\ 35)}$=5.09, p<.05]. The SME result indicated that participants with low self-efficacy showed higher scores of task performance in KORI than in peer tutoring [$t_{(19)}$=-2.807, p<.05], whereas there was no significant difference between conditions in high self-efficacy [$t_{(18)}$=-.138, p>.05].

Table 2. Means and Standard Deviation for Task Performance

Conditions	Self-efficacy	MEAN	SD	N
Peer tutoring (N=20)	High	16.50	1.64	10
	Low	13.75	.05	10
Teachable agent(TA), KORI(N=21)	High	16.62	2.20	10
	Low	17.37	1.99	11

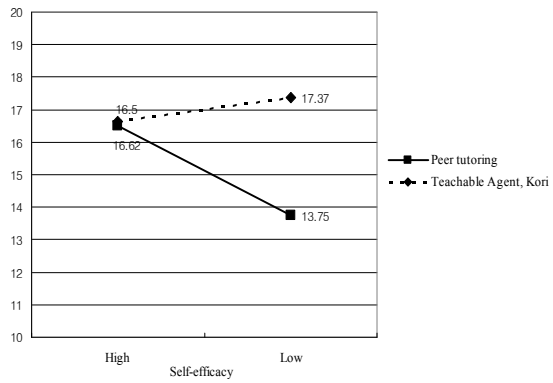

Figure 6: Task performance's scores by peer tutoring/KORI and self-efficacy

Conclusions

Peer tutoring and the TA, KORI, were compared in terms of interest and task performance according to the level of self-efficacy. The high self-efficacious group showed more interest in peer tutoring than in KORI, while the low self-efficacious group exhibited a reverse interest. In task performance, participants with high self-efficacy received higher scores in both peer tutoring and KORI, whereas participants with low self-efficacy gained higher scores in KORI than in peer tutoring. Actually, previous studies have demonstrated positive effects on academic achievement and motivation to learn (Cohen et al., 1982). However, our findings were inconsistent with such prior research, particularly in the low self-efficacious group.

We can infer that face-to-face peer tutoring might provide students who have a low self-efficacy with an excessive cognitive burden due to the need to memorize lots of teaching contents (Kim et al., 2003), whereas KORI might make students less anxious and more comfortable with the teaching activity due to the inclusion of various resources and experts able to help the participants. Thus, participants with low self-efficacy revealed higher interest and task performance in KORI, whereas the high self-efficacious

group had low interest in KORI, possibly because they felt monotonous and boring with the teaching activity in KORI. Accordingly, students with high self-efficacy should be provided with a challengeable situation featuring complicated and dynamic, teaching activities.

The present study suffered several limitations. The sample size was small in each condition, and we only examined self-efficacy among individual differences. Future research needs to be expanded to cover other grades and domains such as social studies and science, and also to examine the effect of KORI on other individual variables such as metacognition, goal orientation, cognitive ability in order to continue the development of KORI as an individualized intelligent TA.

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