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A Pilot Study of Computer Supported Learning by Constructing Instruction Notes and Peer Expository Instruction

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Abstract. Learning by teaching has been extensively studied in education and psychology research. However, there has been relatively less effort in this research avenue in CSCL research. Computer supported learning by teaching, as a genus of CSCL activities, is expected to draw more attention in the future. In this pilot study, we propose a model of computer supported learning by teaching that involves peer tutors in preparing their instruction notes and teaching their peer tutees verbally. Collaborative learning is incorporated in our pedagogical design. As an initial investigation and for future improvement of our design, we conducted two experimental trials in a graduate-level course. This paper discusses the design of this model and reports our findings from the experimental trials.

Keywords: computer supported learning by teaching, computer supported peer tutoring, peer teaching, reciprocal peer tutoring, learning by teaching

INTRODUCTION

Students teaching students, or peer tutoring, is a pedagogical strategy studied extensively in the education research. It has been found that having students teach each other increases their achievement at various educational levels (Cohen *et al.*, 1982; Falchikov, 2001; Rohrbeck *et al.*, 2003). Several studies have further shown that tutors academically profit more than their tutees, and the gains are not only from the teaching activity, but also from the pure expectation of a later teaching demand (Bargh & Schul, 1980; Benware & Deci, 1984).

Chan (2004) indicates that teaching represents a repertoire of activities consisting of learning about the materials, composing teaching materials, conducting face-to-face teaching, monitoring learner's work, assessing learner's learning outcomes and affective status, and reviewing their own teaching process. Learning by teaching can be of varied forms, and when peer tutors are involved in different teaching activities, they would learn in different depths and with different perspectives (Chan, 2004). A group of international researchers envision that a computing device will be as indispensable as a pencil for a student in the future (www.G1on1.org). Given such an inevitable trend, Chan points out that the intention of a comprehensive Computer Supported Learning By Teaching (csLBT) model is to have peer tutors cover the teaching activities as many as possible by the supports of one-on-one (1:1) educational computing classroom where every student has a computing device with wireless communication support.

There have been various efforts in designing intra-class peer tutoring, but mainly for "monitoring learner's work" activity; that is, having peer tutors monitor and give immediate feedback or help when tutees are doing exercises, for example, Class-Wide Peer Tutoring (Greenwood *et al.*, 1989), Reciprocal Peer Tutoring (Fantuzzo *et al.*, 1992), and ASK to THINK-TEL WHY (King, 1997). These approaches are similar in the way that they conduct reciprocal tutoring by asking tutees questions which are either structuralized or provided from the class teacher and are held in the situation that both tutors and tutees have read or been taught about the target subject.

This pilot study proposes a model of csLBT which addresses on learning by constructing instruction notes and peer expository instruction. The proposed model involves students in three teaching activities—learning about the materials, composing teaching materials, and conducting face-to-face teaching—by the supports of 1:1 educational computing classroom. Collaborative learning plays a crucial element in our pedagogical design. Two experimental trials were conducted in a graduate-level course to explore (a) how this model can motivate

tutors to learn, (b) what and when tutors and tutees would benefit from the model, and (c) how much students would prefer this model to be used in their courses regularly.

MODEL AND SYSTEM DESIGN

There are three phases in the proposed csLBT model. The first two phases are related to learning by teaching and the last phase is to complement the first two phases with instructor-led discussion.

Preparation phase

This phase consists of four sub-phases: (1) *Learning about the materials*. The class instructor prepares materials for two different topics, then arranges the class into two groups and assigns each group to study a topic for preparing to teach the other group. This design is for every student to has equal chance of learning by teaching. With the intention of explaining to others, students would pay more efforts in their individual learning. (2) *Constructing individual instruction notes*. Every student has to compose instruction notes after studying the assigned material and submit to the csLBT system. This step facilitates tutors to identify and organize main ideas, and shapes their thoughts concretely. (3) *Peer assessment.* Peers in the same group assess each other's instruction notes anonymously. Not only this step can release the teacher from grading works, but also provide tutors the chance to reflect on their own products. (4) *Collaborating for common instruction notes*. Instead of using individually designed instruction notes to teach, students are paired in the same group and each pair has to "merge" their notes into a common one for their later teaching. The sub-phase is designed for facilitating tutors to explain their own rationales, coordinate and integrate alternative perspectives, and produce a better instruction note than they have down individually. Figure 1 shows a system to support these sub-phases.

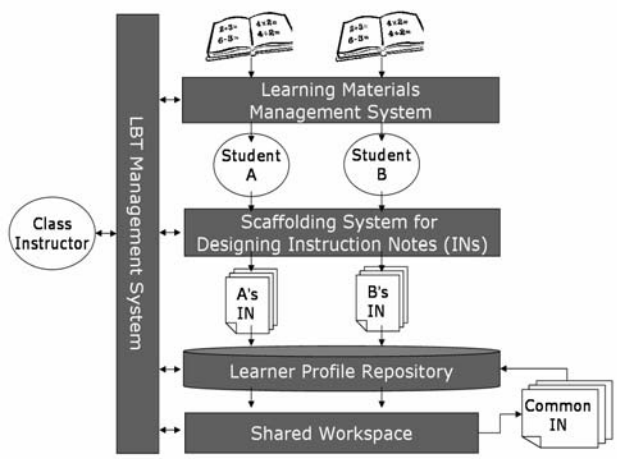

Figure 1 System design of the *preparation* phase

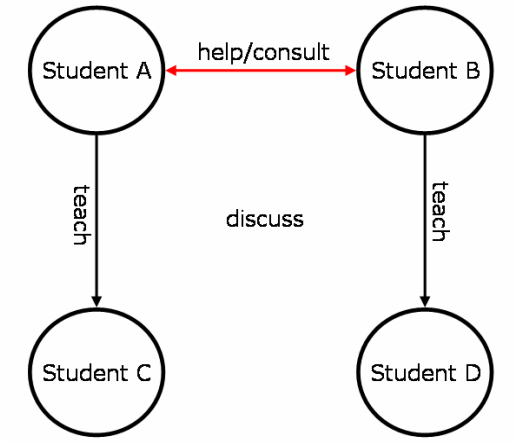

Figure 2 The interaction model during the *peer teaching* phase with the supports of 1:1 educational computing classroom

Peer teaching phase

This phase consists of two sub-phases: (1) *Conducting expository instruction*. As demonstrated in Figure 2, A teaches C and B teaches D where C and D are from the other group. A and B are teaching with their common instruction notes and helping each other. The one-on-one tutoring design is for augmenting each student's benefits by the intensive interactions. And the design of two tutor-tutee pairs as a group helps discussion when alternative perspectives are needed. (2) *Answering questions and group discussion*. Every student answers questions distributed by the class instructor and then A, B, C and D, as a small group, share and discuss their answers. During this phase, students interact with each other face to face with the supports of 1:1 educational computing classroom where all students are equipped with wireless-enabled laptops or Tablet PCs. These devices allow students for accessing and presenting learning materials and the common instruction notes, and sharing and revising the answers in the second sub-phases.

Instructor-led discussion phase

The class instructor explains the answers of the questions in the peer teaching phase and gives complementary instruction if needed. With the supports of 1:1 educational computing classroom, the instructor can view all reported answers and then adjust her explanations and complementary instruction. She can also present some selected student answers and hence enrich the class discussion. We expect the *answering questions and group*

discussion sub-phase and *instructor-led discussion* phase are especially important for the peer tutees as these phases verify the qualities of peer tutoring and their own learning and provide the second chance to be taught.

EXPERIMENTAL TRIALS AND INITIAL INVESTIGATIONS

Students enrolled in or auditing a graduate-level seminar course on "Intelligent Tutoring Systems" participated in these experimental trials. A total of 26 graduate students, including seven doctoral students and two postdoctoral students, participated in the first trial, and half of them taught the other half. In the second trial, 22 students in the class, including six doctoral students, participated owing to absence of four students. Those who were tutees in the first trial acted as tutors in the second trial. Participants were grouped and paired randomly. No incentives, such as increasing grades or passing exams, were given for their participation so that we can see how the model itself can motivate students.

The *preparation* phase took participants two weeks before the *peer teaching* phase. In each trial, both *peer teaching* phase and the *instructor-led discussion* phase were held in a three-hour class meeting. The *conducting expository instruction* sub-phase took one and half hours, the *answering questions and group discussion* sub-phase took one hour, and the class instructor led a whole class discussion about the questions and provided topic review in the rest class time.

The prototype of csLBT system was supported by two existed systems. EduX (Chang *et al.*, 2003) supports activities in the *preparation* phase via Internet. Digital Classroom Environment (DCE) (Deng *et al.*, 2004) supports the other two phases and every participant is equipped with a wireless enabled Tablet PC. The major functions supported by DCE are questions distribution, individual answers reporting and storage, sharing reported answers among the small group members, and viewing all the reported answers—a function for the class instructor. Figure 3 is a screen shot of DCE drawing panel functioning in the share mode—all group members' answers are displayed in the small boxes in the bottom and can be displayed in the bigger box for shared workspace or legibility by clicking one of those small boxes. Any modification will be displayed synchronously. Figure 4 depicts members in a small group revisiting the materials after finding the differences among their answers via the share mode of DCE.

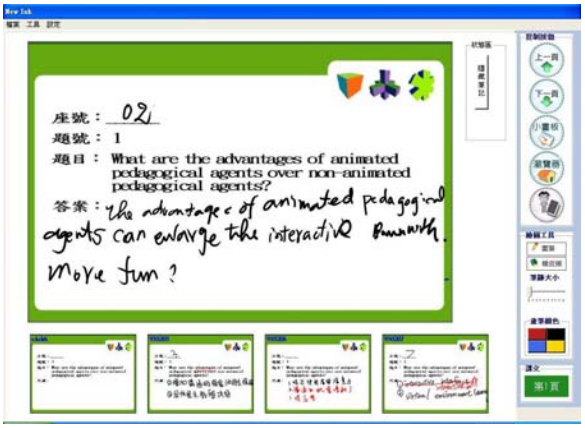

Figure 3 A student using DCE (share mode) to share and discuss answers with other members.

Figure 4 Small group members in their learning during the discussion session

After the experimental trials, 12 participants were interviewed about what they learnt and what had driven them to learn in each sub-phase. All the interviews were tape-recorded. Some selected feedbacks were excerpted in Table 1.

Table 1 Some feedbacks from participants during the interviews

Sub-phases	Excerpts from the interviews
1-1 Learning about the materials	*"...If you can't teach yourself, how can you teach others? So I tried my best to understand the assigned material."* (motivation for full comprehension) *"When I have to teach somebody, I have to make sure the ideas I get from the assigned material are 'really' what the material means, so that my tutee won't get wrong ideas because of me, or I'll be very sorry..."* (commitment to teach correctly)
1-2 Constructing individual instruction notes	*"Besides the slides* [instruction notes] *shown on the laptop, I additionally provided more detailed summaries in my instruction scripts..."* (paying more efforts) *"As we were going to compose the notes for others to learn, so I structured my notes so that they are composed of several sessions."* (creating ways for organizing knowledge)
1-3 Peer Assessment	*"The assessing rubrics should have been provided earlier...because they could have served as a guide for composing my own instruction notes."*
1-4	*"We found the content* [some concepts] *was talking about the same things, although their*

Collaborating for the common instruction notes	*terminology or perspectives were different. So we put them together and linked with the similar concepts mentioned in the previous classes…"* (linking and integrating ideas) *"We arranged them* [instruction notes] *chronologically, talking about the origins, the evolution, and the problems it was facing…"* (re-sequencing according to a certain structure) *"These are talking about functions and usages, and those are talking about solutions…"* (categorizing topics) *"I really enjoyed the collaboration with my partner for working out our common instruction notes. It's not just like labor division—the usual way we use for tasks like group reports. This is a real collaboration."* (positive affective outcomes and intellectual collaboration)
2-1 Conducting expository instruction	*"My tutee asked something I couldn't explain according what I learnt, then I revisited the original material, and then I realized I had misunderstood that part."* (repairing knowledge) *"My tutee asked a question that I couldn't answer. We checked the paper together and found it was mentioned in the paper."* (finding missing knowledge) *"After I provided further elaboration for an idea that my tutee found confusing, my tutee kept nodding and saying 'I got it!' And that made me feel so great… "* (sense of achievement) In the views of peer tutees: *"I was fully concentrated during the whole process. Because, you know, how can you be distracted when you're the only person whom somebody is looking at and talking to?"* (social obligation and hence concentration) *"I asked every question emerged from my mind when my tutor was teaching. Although he was teaching me, I felt we were more like partners and we were discussing. I usually don't ask many questions in the class because they might be regarded as silly questions."* (individualized instruction)
2-2 Answering Questions and group discussion	*"The main sense of achievement came from when my tutee answered the questions correctly—that meant my teaching worked…"* (sense of achievement) *"I felt sorry when the tutees had no ideas about the answers—I missed mentioning that part." "I think that tutors learn more in such activities…It seemed that my tutee couldn't digest what I had taught because he failed to answer so many questions…"* (frustration because the tutor could not tutor his tutee well enough) In the views of peer tutees: *"My tutor taught me a lot of things, and those things were scattered in my brain unorganized. Answering the questions helped me categorize the knowledge I had just been told, knowing what belongs to what…"*
3 Instructor-led discussion	In the views of peer tutees: *"Explanations from the instructor were very important, because there were some questions even my peer tutor was not sure about the answers. And I also would like to learn more from the perspectives of the instructor as well as the other small groups."* *"The instructor's explanation was well-organized, so I got a clearer picture about the topic my tutor taught me."*

Besides the interviews, participants were requested to fill in a questionnaire asking them to rank the value of each sub-phase for their learning, from both perspectives of the tutor and the tutee. From the tutor's perspectives, participants ranked the *learning about the materials* phase the highest, the *constructing individual instruction notes* and *collaborating for the common instruction notes* as the second, then the last three sub-phases but in the order of *conducting expository instruction*, *instructor-led discussion*, and *answering questions and group discussion*, and *assessing peers' instruction notes* as the last. From the tutee's views, however, the ranks of the last three sub-phases (in-class sub-phases) are reversed, that is, *instructor-led discussion* phase the highest, then *answering questions and group discussion*, and *conducting expository instruction* as the last.

Another item in the questionnaire is how often the student wishes to use this model in a course. Only five percent of participants wished to use it every time the class meets. 55 percent of participants agreed that this model can be used about half of the times the class meets. 35 percent of participants preferred using it less than half of the course. No one wished not to use this model in any class. Five percent of participants left this item unanswered. In the interviews, participants explained that although this model facilitated learning, the preparing phase was time-consuming for tutors.

DISCUSSION AND FUTURE WORKS

Many positive impacts on peer tutors' learning, both in affective and cognitive domains, are found from the interviews. They were motivated to study carefully and thoroughly because of the commitment to teach

correctly and to help others. This kind of intention to comprehend, as Brown (1988) suspected, may be the critical reason that makes the "reciprocal teaching" strategy successful. They sensed satisfaction when clearing their tutees' confusions up and helping them answer the instructor's questions correctly. They *cared* about how their tutees learnt. Higher-level cognitive gains, e.g. actively linking, integrating, organizing the knowledge they learnt, mainly came from the phase of merging two different instruction notes—just as one interviewee said: "*It is the real collaboration*." By teaching others, misunderstandings were repaired and knowledge was consolidated. Moreover, positive learning attitudes were also elicited because tutors have intensive interactions with their partners and tutees. We also find that, despite age and seniority differences, the efforts that peer tutors paid for preparing teaching were not affected by whom they were going to teach, although they felt pressured when their tutees are more senior, for example, doctoral students.

From the interviews with tutees and their questionnaires, however, we found that peer tutees would not have been satisfied if they had just been being taught by peer expository instruction. After being tutored, tutees found that they are more eager for having the opportunity of actively organizing the knowledge just newly learnt and treasure the instructor's inputs in the last phase as this ensures and enriches what they learnt. This finding supports our expectation that the two designs, *answering questions and group discussion* sub-phase and *instructor-led discussion*, will be especially important for tutees' learning. Nevertheless, it also suggests that a basic tutoring training can and should be supported by the system, or students may not know how to perform an effective instruction. Hence, scaffolding mechanisms supporting peer tutors for their preparation and teaching processes are essential for the csLBT system and will be one of our future works. Another future work of this research is to engage tutees both in the preparation and peer teaching phases, instead of being tutored passively.

Generally speaking, this pilot study suggests that by involving students in composing instruction notes and teaching their peers, graduate students can learn actively and both tutors and tutees are immersed in such learning context, even though there is no incentive provided. Therefore, further development is worthwhile for building more useful tools and scaffoldings for this csLBT. However, there are some issues that have to be seriously considered when designing such a system. First, the works for tutors in the preparation phase are time consuming. Second, the class instructor may concern about student's tutoring quality. He is sure what he said is right in the class though he does not know whether students understand or not. But in the proposed csLBT model, he is not fully confident whether student tutors can correctly teach the materials. Finally, the learning chances may be unequal between peer tutors and peer tutees since peer tutors may gain more than their tutees. Some carefully designed experiments comparing the learning effects of csLBT for graduate students and other common teaching strategies should also be conducted.

REFERENCES

Bargh J. A., & Schul Y. (1980) On the cognitive benefits of teaching. *Journal of Educational Psychology*, **72**, 5, 593-604.

Benware C. A., & Deci E. L. (1984) Quality of learning with an active versus passive motivational set. *American Educational Research Journal*, **21**, 4, 755-765.

Brown, A. L. (1988). Motivation to learn and understand: On taking charge of one's own learning. *Cognition and Instruction*, **5**, 4, 311-321.

Chan, T. W. (2004) Computer supported learning by teaching. Unpublished paper submitted to CSCL2005.

Cohen, P.A.; Kulik, J.A.; Kulik, C.L.C. (1982) Educational outcomes of tutoring: a meta-analysis of findings. *American Educational Research Journal*, **19**, 237-248.

Chang, L. J., Yang, J. C., Deng, Y. C., & Chan, T. W. (2003) EduXs: multilayer educational services platforms. *Computers & Education*, **41**, 1, 1-18.

Deng, Y. C., Chang, L. J., Chang, S. B. & Chan, T. W. (2004). DC-1: Support of Digital Classroom Learning Environment with Wireless devices. Unpublished paper submitted to *Journal of Innovations in Education and Training International*.

Falchikov, N. (2001) *Learning together: Peer tutoring in higher education.* London: RoutledgeFalmer.

Fantuzzo, J. W., King, J. A., & Heller, L. R. (1992) Effects of reciprocal peer tutoring on mathematics and school adjustment: A component analysis. *Journal of Educational Psychology*, **84**, 3, 331-339.

Greenwood, C. R., Delquadri, J., & Hall, R. V. (1989) Longitudinal effects of classwide peer tutoring. *Journal of Educational Psychology*, **81**,371-383.

King, A. (1997) ASK to THINK-TEL WHY: A model of transactive peer tutoring for scaffolding higher level complex learning. Educational Psychology, **32**, 4, 221-235

Rohrbeck, C. A., Ginsburg-Block, M. D., Fantuzzo, J. W., & Miller, T. R. (2003) Peer-Assisted Learning Interventions With Elementary School Students: A Meta-Analytic Review. *Journal of Educational Psychology*, **95**, 2, 240-257.