EFFECTS OF PEER-TUTOR COMPETENCES ON LEARNER COGNITIVE LOAD AND LEARNING PERFORMANCE DURING KNOWLEDGE SHARING

Ya-Ping (Amy) Hsiao, Francis Brouns, Jan van Bruggen and Peter B. Sloep
Centre for Learning Sciences and Technologies (CELSTEC), Open University of the Netherlands
P.O. Box 2960 6401 DL Heerlen The Netherlands

ABSTRACT

In Learning Networks, learners need to share knowledge with others to build knowledge. In particular, when working on complex tasks, they often need to acquire extra cognitive resources from others to process a high task load. However, without support high task load and organizing knowledge sharing themselves might easily overload learners' limited cognitive capacities because learners first have to find relevant peer tutors (i.e., those who provide help) and then maintain the social interaction. We propose to design a peer-support system that selects tutors and provides support during knowledge sharing. The pilot study reported here investigated the effects of two peer tutor competences, tutoring skills vs. content knowledge, on tutees' (i.e., those who need help) cognitive load and learning performance. The results show that tutees supported by tutors with tutoring skills experienced lower cognitive load and had better learning performance than did tutees supported by tutors with content knowledge. This is in line with our assumption, but for confirmation we need to gather more data in a full study. We need to first use a task that requires learners to rely on others to trigger higher cognitive skills to deal with high task load. Secondly we need to find a modus to ensure that the tutors follow the instructions to apply the particular competence.

KEYWORDS

Peer-tutor competence, content knowledge, tutoring skills, knowledge sharing, cognitive load, tutor selection.

1. INTRODUCTION

A Learning Network (LN) is a particular kind of online social network that is dedicated to learning (Sloep 2009). In LNs, learners are themselves responsible for sharing knowledge with their peer learners. When organizing knowledge sharing themselves, learners first have to find out relevant knowledge sharers and then maintain the social interaction with others to reach a shared understanding and knowledge building. To help finding relevant knowledge sharers, our colleagues have developed two tutor selection systems that automatically assign peer learners with relevant content knowledge to act as peer tutors to help answer each others' content-related questions (Van Rosmalen 2008; De Bakker 2010). However, due to the heterogeneous group composition of LNs it is not always possible to find tutors with content knowledge related to tutees' questions. In addition, the questions or problems that participants of LNs have are often rather complex: they are authentic problems originating from real-life contexts, such as the working place. When working on complex tasks, learners have to allocate many of their cognitive resources to process numerous information elements and element interactivity and this imposes a high cognitive load (Sweller et al. 1998). Cognitive load (or mental workload) refers to the learner's limited cognitive capacity actually allocated on performing a particular task and it has been recognized as an important factor that influences learner performance (Sweller et al. 1998; Hart 2006). We surmise that tutors who provide content-related knowledge *only* cannot alleviate their tutees' cognitive load.

Furthermore, maintaining the social interaction to reach a shared understanding or build knowledge on complex tasks requires certain pedagogical and process-facilitation skills (King 2007; Roscoe and Chi 2008). These skills go beyond the knowledge transfer or information exchange that content tutors often offer. If it is not possible to always find tutors with content knowledge precisely related to tutees' questions, nor do tutors with content knowledge guarantee effective tutee learning, it is therefore necessary to consider tutors with

tutoring skills. However, while most tutoring studies have examined effects of tutors' content knowledge on diverse dependent variables of tutees, there have *not* been many studies that measured effects of tutors' tutoring skills on tutees' learning. Studies of *reciprocal* peer tutoring have compared the effects of supporting learners *with* and *without* tutoring skills on learner performance (King 1994; King et al. 1998; Nath and Ross 2001). Their support of tutoring skills was to make sure that learners would demonstrate tutoring skills to elicit certain social interactions and trigger cognitive processes that contribute to learning. Some studies have shown that the learners with tutoring skills outperformed the control groups on knowledge or comprehension tests (King 1994; King et al. 1998). However, in LNs knowledge sharing involving peer support is more akin to *asymmetric* rather than reciprocal peer tutoring. From these studies we can therefore only speculatively claim that tutoring skills are likely to promote tutee learning. Considering human limited cognitive capacities, we need to redesign our previous tutor selection system to figure out what makes an effective tutor and to design support for the social interaction process. To achieve this, we first of all need to investigate the effects of peer-tutor competences, i.e. content knowledge vs. tutoring skills, on tutee learning. In this pilot study we investigate whether it is possible to determine an effect of the two types of peer-tutor competence when tutors do not receive prior training but instead receive a tutoring guide to follow.

2. METHOD

Two computer science classes jointly consisting of 28 students from a pre-university secondary school in the Netherlands took part in this pilot. We assigned students in half of classes to act as tutors and the other half as tutees. The tutor role was split: a tutor was either a tutoring skills (TS) or a content knowledge (CK) tutor. In total there were seven TS and seven CK pairs. The intervention of this study was to provide tutors with a tutoring guide including additional course materials (for CK tutors) or instructions of tutoring skills (for TS tutors) to assure that tutors had either CK or TS competence. The instructions that TS tutors received consisted of general rules for pedagogical and process-facilitation skills as well as specific step-by-step directions that guide tutors to perform pedagogical and process-facilitation skills (King 2007). This study consisted of two sessions in 2.5 hours. Two websites were set up for these two sessions: the course site contains the learning material of *Sex and Evolution* as well as the task site contains task instructions, chat and wiki tools. During the first session, students studied the learning material on the course site and then they took the pre-test and filled in the Tutoring Skills Questionnaire. There was a 15-minute break between these two sessions. The second session was started with a brief introduction of peer tutoring, task requirements and use of chat and wiki tools. Then students had 50 minutes to work in pairs to complete the essay task. While performing the task, students no longer could consult the course material. When working on the task, students had to use a chat to communicate with each other and they were not allowed to talk face-to-face. Tutees had to write the essay in a wiki and to "publish" the wiki page frequently to allow the tutors to read up on the tutee's progress. Tutors could only read the wiki page, but they could not edit it. To view the updated wiki page, tutors had to "refresh" the wiki page frequently. Tutors used a respective tutoring guide to help tutees work on essay answers through the chat. After the task, students had 20 minutes to indicate experienced cognitive load on the NASA-Task Load Index (see Table 1) (Hart 2006), to take the post-test and to fill in an evaluation survey.

3. FINDINGS

Pre-measures. Both groups of tutees estimated their tutoring skills to be quite high, 63 out of possible 75. The low pre-test scores showed that tutees of both groups did not have sufficient prior knowledge though TS tutees scored slightly higher than CK tutees. For both pre-measures, there was no difference between tutees assigned to TS or CK pairs.

Tutee learning performance. Tutees' low post-test scores indicated that working on the essay task did not help students learn much related to the course materials. In addition to the same items of the pre-test, there were five task-related items in the post-test. CK tutees performed better on five task-related items than TS tutees: this means that additional course materials might help tutees understand the topics included in the essay task better than instructions of tutoring skills. Both groups of tutees performed equally well on essay

answers though TS tutees performed slightly better than CK tutees. Qualitatively, TS tutees answered more topics completely than CK tutees whereas CK-tutees answered more topics partially than TS-tutees.

Tutee cognitive load. TS tutees' total cognitive load is lower than CK tutees' and lower on all six dimensions. In particular, TS tutees experienced much lower cognitive load on *physical demand* and *frustration* than CK tutees.

Table 1. Tutee cognitive load on six dimensions of NASA-TLX

		Mental demand	Physical demand	Temporal demand	Performance	Effort	Frustration	Total
TS	Median	12.00	3.00	10.00	6.00	9.00	2.00	41.00
	SD	4.27	3.82	6.05	3.70	4.08	5.68	14.60
CK	Median	14.00	11.00	10.50	8.00	13.00	10.50	68.00
	SD	5.59	4.32	4.66	4.67	3.93	2.78	20.01

Tutee cognitive load and learning performance when their tutors applied the tutoring guide. Chats were analyzed for evidence of adherence to the assigned tutoring competence. Only two of the TS tutors applied the *specific* step-by-step instructions and five of the CK tutors referred to the additional course material. Table 2 shows that TS tutees performed better on all performance measures and they experienced lower cognitive load than CK tutees.

Table 2. Performance measures and cognitive load of TS tutees and CK tutees supported by tutors who actually applied intervention during chats

	TS-tutees (n = 2)		CK-tutees (n = 5)	
	M	*SD*	*M*	*SD*
pre-test	5.00	2.83	3.75	.96
post-test	6.50	3.54	4.40	1.52
5 task-related items	4.00	0	3.60	1.67
essay	7.92	1.29	6.71	1.78
total cognitive load	51.00	14.14	68.20	10.85

4. CONCLUSION AND DISCUSSION

Although TS tutees had higher scores on the essay task and post-test, CK tutees seemed to have higher scores on the five task-related items than TS tutees. From how multiple topics were answered in the essays, we surmise that the different tutor competences influenced how tutees worked on the task. The diverse examples included in the additional course materials helped CK tutees answer more topics partially while the instructions that TS-tutors used helped TS tutees answer topics more completely. When looking into the data of tutees supported by tutors who *indeed* applied the intervention of additional course materials and tutoring skills, the results in Table 2 turned out to be different from the group data: TS tutees performed better than CK tutees on both test and task measures. During knowledge sharing, CK tutees in general experienced more cognitive load than TS tutees. In particular, the much lower score on *frustration* corresponds to findings of our previous study (Hsiao et al. in press). We observed that some CK pairs completed the task much earlier than the expected time of 50 minutes. Although using additional course materials helped CK tutees complete the task earlier, CK-tutees still indicated a high cognitive load.

The findings of this pilot are hopeful in the sense that discerning CK and TS tutoring competences seems to make sense. In order to corroborate our first findings, we need to improve three aspects for the full study. First, in this study we tried out different performance measures in order to find out which could clearly answer the research question in the full study. The pre- and post-test that measured students' understanding of the entire course could not appropriately gauge the effects of the intervention on the essay task since this essay only covered several topics of the course. Thus, to better measure learning performance, we should either expand the number of task-related items to a longer test or use the essay answers that directly reflect how students learn from working on the task. Second, tasks with different complexities require different amount of cognitive resources to deal with the task load. Complexities of essay questions not only depend on the interactivity of information elements but also on the level of cognitive skills required. The essay question

of this study is still a relatively *simple* task: comparing and contrasting facts require a lower level of cognitive skills, namely understanding. From satisfactory essay scores, we surmise that tutees might be able to answer the essay by merely retrieving learned factual knowledge from their own or their tutors' memory instead of performing higher cognitive skills to process the task load. This corresponds to our model that when working on simple tasks learners do not need to resort to knowledge sharing or that knowledge sharing does not contribute to better learning effects (Hsiao et al. 2011). Third, considering the online characteristics of LNs, we supported tutors with certain competences by giving them ready-to-use tutoring guides instead of giving them a prior training, as is commonly done in online collaborative learning studies or peer tutoring in face-to-face classrooms. The results showed that five of seven CK tutors and two of seven TS tutors and applied the respective intervention. Our findings confirm the findings of peer tutoring studies: without training, peer tutors seldom demonstrate certain skills to fulfill their role tasks (Nath and Ross 2001). Our observations during the experiment might explain why TS tutors did not use tutoring skills: i) tutors might not have sufficient time to read all of the textual instructions, ii) tutors might not realize the relevance of using the general instructions with answering the essay question, and iii) students might have developed certain internal scripts of dealing with such essay questions comparing facts and thus they did not need to use our intervention.

To conclude, for the full study we need to *oblige* tutors to apply the support of competences as we expected, in particular for tutors to apply tutoring skills. In addition, we should implement the full study with a more complex task that requires higher-order cognitive skills such as analysis, evaluation and synthesis, to make sure that learners benefit from the kind of knowledge sharing with others that triggers extra cognitive processes.

REFERENCES

De Bakker, G., 2010. *Allocated online reciprocal peer support via instant messaging as a candidate for decreasing the tutoring load of teachers*. PhD doctoral dissertation, Eindhoven University of Technology.

Hart, S. G., 2006. NASA-Task Load Index (NASA-TLX): 20 Years Later. *The Human Factors and Ergonomics Society 50th Annual Meeting*. Santa Monica: HFES., San Francisco, pp. 904-908.

Hsiao, Y. P., et al., 2011 Cognitive load and knowledge sharing in Learning Networks. *Interactive Learning Environments*, pp. 1-12. DOI: 10.1080/10494820.2010.548068.

Hsiao, Y. P., et al., in press. Designing optimal peer support to alleviate learner cognitive load in Learning Networks. *IADIS International Conference Web-Based Communities and Social Media 2012*. Lisbon, Portugal.

King, A., 1994. Guiding Knowledge Construction in the Classroom: Effects of Teaching Children How to Question and How to Explain. *American Educational Research Journal*, Vol. 31, No. 2, pp. 338-368.

King, A., 2007. Scripting Collaborative Learning Processes: A Cognitive Perspective. In F. Fischer, I. Kollar, H. Mandl and J. M. Haake (Eds.), *Scripting Computer-Supported Collaborative Learning* (pp. 13-37). Springer US, New York, NY.

King, A., et al., 1998. Mutual peer tutoring: Effects of structuring tutorial interaction to scaffold peer learning. *Journal of Educational Psychology*, Vol. 90, No. 1, pp. 134-152.

Nath, L. R. and S. M. Ross, 2001. The influence of a peer-tutoring training model for implementing cooperative groupings with elementary students. *Educational Technology Research and Development*, Vol. 49, No. 2, pp. 41-56.

Roscoe, R. D. and M. T. H. Chi, 2008. Tutor learning: the role of explaining and responding to questions. *Instructional Science*, Vol. 36, No. 4, pp. 321-350.

Sloep, P. B., 2009. Fostering Sociability in Learning Networks through Ad-Hoc Transient Communities. In M. Purvis and B. T. R. Savarimuthu (Eds.), *Computer-Mediated Social Networking* (pp. 62-75). Springer, Heidelberg, Germany.

Sweller, J., et al., 1998. Cognitive Architecture and Instructional Design. *Educational Psychology Review*, Vol. 10, No. 3, pp. 251-296.

Van Rosmalen, P., 2008. *Supporting the tutor in the design and support of adaptive e-learning*. PhD doctoral dissertation, Open University of The Netherlands.