Construction of Shared Knowledge During Collaborative Learning

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Abstract

This study reports preliminary findings from a study that investigated (1) the kind and extent of shared knowledge constructed after collaborative learning and (2) the relationship between the construction of shared knowledge and individual learning. In this study, college dyads collaborated to learn a biology concept. Preliminary findings showed that pairs shared similar mental models and knowledge pieces after collaborative learning and that the amount of collaborative knowledge is related to the amount of learning. Such results suggest that pairs engage in shared learning activities during collaboration which seems to lead to increased learning. Ideas for further analysis are discussed as well as implications of this study for a computer support system for collaborative learning.

Introduction

Various studies have demonstrated that collaboration is beneficial (Azmitia, 1988; Doise, Mugny, & Perret-Clermont, 1975, 1976; Ellis, Klahr, & Siegler, 1993). Although these benefits are not universal and vary across tasks and individual students (e.g., Tudge, 1989), students seem to learn better or solve more problems correctly when they collaborate with other people, especially when the task is conceptual and complex (Gabbert, Johnson, & Johnson, 1986). Collaboration also seems to have other beneficial effects such as improving social relations, or increasing students' motivation (Sharan, 1980). Thus, for various reasons, collaboration is increasingly viewed as an effective instructional medium. More and more educators are assigning collaborative work in their classrooms, and computer support systems for collaborative learning are receiving increasing attention.

Despite such popularity, however, the exact mechanism of collaborative learning is not yet well understood. While researchers have proposed that several factors such as cognitive conflicts (Doise et al., 1975, 1976), partner expertise (Azmitia, 1988), or increased amount of verbalization (Teasley, 1992) are responsible for improving learning in collaboration, these factors do not provide an explanation of how collaboration actually works. Moreover, there are several empirical studies that contradicted these factors, showing that the effect of collaboration does not seem to depend solely on the expertise of the partner (Ellis et al., 1993), the presence of cognitive conflict itself (Bryant, 1982), or sheer amount of talking itself (Perlmutter, Behrend, Kuo, & Muller, 1989).

A basic premise of social interaction is the need to achieve a "common ground" that makes communication possible (Clark & Brennan, 1991; Clark & Schaefer, 1989). Based on the reports in anthropology, linguistics, and the organizational sciences, it seems that people share common memories, knowledge, or mental models as a result of working together (Hardin & Higgins, 1996; Klimoski & Mohammed, 1994; Sherif, 1936). The same process of achieving a shared representation may be occurring during collaborative learning. Collaborative learning has been considered a process of convergence in which people gradually converge on a meaning and achieve a shared representation (Roschelle, 1992). Thus, one could argue that construction of a shared representation is one mechanism that may explain how people learn during collaborative learning.

However, few studies have examined whether shared representation is actually achieved as a result of collaborative learning. Also, little evidence yet links the amount of learning to the construction of shared knowledge. Thus, the following two questions are addressed in this study: (1) Do people construct a shared representations during collaboration? That is, what kind and how much sharing is actually achieved between collaborating individuals? (2) Does the extent of sharing among interacting partners account for improved learning in each individual partner? In other words, do students who share more knowledge also tend to learn more as a result of collaboration?

To answer these questions, college student dyads were asked to collaborate in learning about a biology concept, the human circulatory system. Detailed assessment of what participants learned about the human circulatory system examined the extent of shared knowledge between partners as well as the amount of knowledge that they learned.

Method

Twenty-two dyads, composed of University of Pittsburgh undergraduates, participated in this study for course credits. Participants had not taken any college-level biology or nursing classes. All the dyads were of the same gender (9 male and 13 female dyads) and race (3 African American and 18 Caucasian dyads).

During pre-test, participants were individually tested on the following two tasks: (1) Terms task in which participants were asked to explain to the experimenter everything they knew about 19 terms about the human circulatory system and (2) a Blood Path drawing task (BP task) in which participants were asked to draw and to talk about the blood path around the body on an outline of the human body.

In the second session, participants were paired with another student of the same gender and race and were asked to collaborate to learn the text on human circulatory system. The text used in Chi, de Leeuw, Chiu, and LaVancher (1994), originally taken from a high school biology textbook, was used with minor revisions: text lines that are not directly relevant to the human circulatory system (e.g., composition of blood) were deleted. The resulting text contained 73 sentences.

The third session was scheduled roughly a week after the collaborative session. Participants were tested individually on the Terms task and the BP drawing task. Participants also answered a set of knowledge questions: these questions—previously referred to as Category 1-3 and Health questions—were designed to tap into different levels of understanding that students learn about the materials. (See Chi et al., 1994, for a detailed description of how the questions were constructed.) All the sessions were audio taped and later transcribed.

Results

Preliminary results from three pairs are reported here. Students' answer to the Terms and BP Tasks (both talking and drawing) during pre-test and post-test are analyzed. First, Students' mental models about the circulatory system were assessed based on what they talked about and drew during the BP task. Their mental models were categorized into one of the seven mental models captured in earlier studies (Chi et al., 1994; Jeong, Siler, & Chi, 1997). (See Figure 1.) Second, a coding template that consists of individual knowledge pieces was used to score their answer. Each knowledge pieces correspond roughly to propositions (e.g., the heart has four chambers) and are either directly stated in the text or can be inferred from the text. Students were credited with knowing pieces of knowledge if they manifested that knowledge through either talking or drawing.

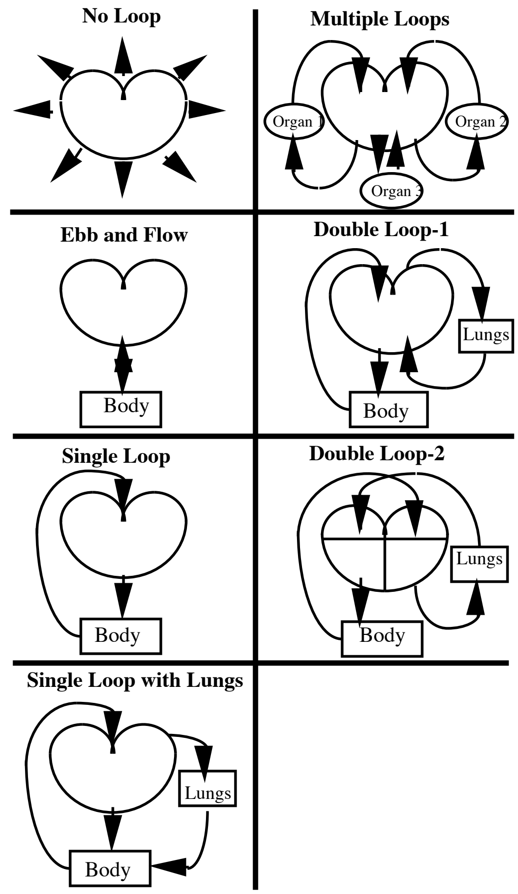

Figure 1. Seven mental models of the human circulatory system.

What kind and how much shared knowledge is co-constructed during collaboration?

The mental models of the circulatory system that each partner possessed during pre-test and post-test were determined based on their drawing and talking during the BP drawing task. All the pairs had different initial models in the pre-test (in all three pairs, one partner had a Single Loop model, and the other partner had a Single Loop with Lungs model). In the post-test, all three pairs shared the same mental (the Double Loop-2 model).

The fact that all three pairs shared the Double Loop-2 model, the most correct model, does not necessarily mean that they co-constructed the model together. Each student working separately could easily have constructed the same correct model even though their initial models were different. Co-construction can only be validated if the pairs made errors. One of our pairs, Pair 1, did have an error in their Double Loop-2 models. In this case, both members of the pair committed the same error (see Figure 2): incorrectly thinking that blood from the lungs returns to the left bottom chamber (i.e., the left ventricle) rather than to the left top chamber (the left atrium).

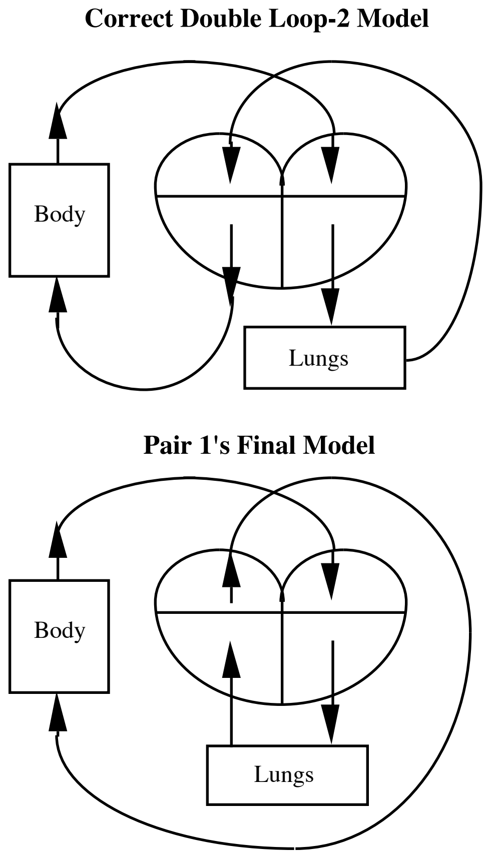

Figure 2. The correct Double Loop-2 model and the incorrect Double Loop-2 model that both members of Pair 2 constructed after collaboration.

To estimate the extent that knowledge is co-constructed during collaboration, we also calculated the number of knowledge pieces shared by each pair based on the template coding. Only the knowledge pieces shared on the post-test were included since the knowledge pieces shared from the pre-test cannot be considered an outcome of co-construction. The proportion of the terms shared at the post-test (the number of shared knowledge peices over the total number of knowledge pieces that either of the pair knew) served as an index of shared knowledge. On average, members of the three dyads shared 34% of what they know with their partner: pair 1 shared 47%, pair 2 shared 21%, and pair 3 shared 34%. Note that the amount of sharing is not simply a function of how much individuals know: pair 3 shared less than pair 1, even though its members scored higher on the post-test (see Table 1).

Table 1. The performance of the three pairs on the Definition of Terms task and the Blood Path drawing task

	Pair 1*	Pair 2*	Pair 3*
Pre-test	10.5	15	20.5
Post-test	42.5	36.25	49.25
Gain	32.45	21.25	28.75
Shared knowledge (%)	47	21	34

* The numbers are the average score of each pair.

Do successful pairs tend to share more knowledge?

As reported above, not all pairs shared the same amount of knowledge after collaboration. The next question, then, is whether the extent of sharing can account for variability in learning. To answer this question, the average pre- to post-test gain scores of each pair on the coding template was used to estimate the amount of learning. Table 1 shows that there exists some variability in the amount of knowledge that pairs shared: pair 1 learned the most knowledge pieces (32.45), pair 3 the next (28.75) and the pair 2 the least (21.25). It is important to note that the amount of shared knowledge did not seem to be a function of how much students know. For example, Pair 3, who scored the highest in the post-test, did not necessarily share the most knowledge pieces. It is rather Pair 1, who scored in the middle in the post-test, who had the most shared knowledge. As shown in Table 1, the data show that when pairs shared more knowledge, they also tended to learn more: pair 1 who shared the most (47%) also learned the most, pair 2 who shared the next most (34%) learned the next most also, and pair 3 who shared the least (21%) also learned the least during collaboration. Although we need to wait for more data to get analyzed, it seems that there exists a correlation between the amount of shared knowledge and learning.

Conclusion, Future Direction, and Implications

Based on the findings from the three pairs, it seems clear that some sort of sharing is achieved between collaborating partners. Collaborating partners shared the same mental model after learning even though their initial models were different; they also shared considerable amounts of knowledge pieces. Also, the variability in the amount of shared knowledge that exists in each dyad is related to the amount of knowledge that they learned through collaboration.

Construction of a shared representation, thus, seems to be one mechanism that may explain how people learn during collaborative learning, which often results in the co-construction of shared mental models and knowledge pieces. Such co-construction processes are expected to occur while people are engaged in explanatory activities during collaboration when learning other types of knowledge (e.g., physics) as well. And the shared representation that results from such activities seems to be the basis for efficient team performance such as in pilots flying airplane.

One important question that remains is what kind of co-construction activities occur during collaboration that result in shared knowledge as well as improved learning. More analyses are planned to address exactly what is happening during the interaction itself. One such analysis is to examine the explanatory activities of the students. It has been widely accepted that engaging in active learning such as generating self-explanations is beneficial to learning (Chi et al., 1994). Generating explanations during collaboration, however, is more complicated than generating explanations to oneself: what one generates is often dependent on one's partner's action and explanations are often generated together with a partner rather than alone.

Although it can be expected that both self-constructed and co-constructed explanations are important to learning, one can ask about the relationship between self-constructed versus co-constructed knowledge. It will be interesting to examine how much shared explanatory activities such as co-construction contributed to learning as compared to self-explanation.

Finally, the results of this study have strong implications for designing a computer support system for collaborative learning. First of all, the importance of constructing a shared representation suggests that it is critical for a computer system to provide a external representation in which participants can negotiate their representation. For example, the lack of such an interface to negotiate shared representation may explain why girls playing together on one computer solved more puzzles than those who worked side-by-side on two computers (Inkpen, Booth, Klawe, & Upitis, 1995). The construction of shared representation may be promoted by providing a shared representational medium. Second, while some computer-support systems for collaborative work provide a window in which participants can communicate with each other, they often fail to create social obligation to interact. Often in computer mediated interaction, participants do not need to respond to the other's input unless they want to, and it is quite easy for participants to operate independently. Thus, participants might be "collaborating" in the sense that they are connected through a computer terminal, but there is little interaction of the sort that is the key to constructing a shared representation. For co-construction to occur, participants must not only make a contribution, but must also get their contribution to be accepted by their partner (Clark & Schaefer, 1989). It is thus critical for computer systems that support collaborative learning to create an environment in which participants actively interact with their partner. A deeper understanding of how individuals co-construct knowledge will provide important clues to designing more effective computer supported collaborative learning environments.

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