The Study of Cognitive Development in the Structured Collaborative Learning Task Mediated by Semantic Diagram Tools

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Abstract: This paper presents the findings from a recent study of two collaborative concept-mapping task mediated by semantic diagram tools with grade 7 students (n=25) in an urban high school in Canada. Data was collected from the pre-post paper-based test to evaluate student's understanding of the learning topic and from the Mural map to evaluate student's CPS engagement and interaction in different learning task. The result was that the cognitive development is improved in the structured CPS learning tasks under the mediation of semantic diagram tools. While, the basic understanding, rather than the high level understanding of learning topic is improved. What's more, the CPS interaction, rather than the CPS engagement make the positive contribution to the cognitive development. This finding gives some insight of design of the CPS learning task and semantic diagram tools in the future study.

Keywords: learning task, CSCL, visualization tool, cognitive development, engagement, interaction

Introduction

How to support student's cognitive development in the computer-supported collaborative learning environment is an important research issue. Based on the social-cultural perspective of learning, many pedagogical and technological supports have emerged from CSCL research (Kobbe et al., 2007). The consensus in the field is that collaborative problems solving (CPS) process and outcomes can be improved greatly when they are appropriately structured (Ertl, Fischer & Mandl, 2006). What's more, visualization tools support collaborative problem solving, allowing learners to construct representations jointly, by providing external mental processes in the form of concept maps, diagrams and, and text (Lu, Lajoie & Wiseman, 2010). Therefore, in this study semantic diagram tools are argument with those kinds of visualization tools to support CPS process to maximize the benefit of collaboration for individual cognitive development. The goal of the study is to preliminarily investigate the effect of cognitive development in the structured collaborative learning task mediated by semantic diagram tools. The research questions are: (1) What's the result of cognitive development in the CPS mediated by semantic diagram tools; (2)What's the difference of learner's CPS engagement and interaction in the different collaborative learning task with the mediation of semantic diagram tools; (3)What's the impact of learner's CPS engagement and interaction on the student's cognitive development?

In order to answer those research questions, a designed-based method was employed to create a 4-day CPS learning project with a 7th grade classroom teacher. In the CPS learning project, students worked in various small group configurations to understand topics of food and nutrition, culminating in an activity where they created a healthy food plan. The web-based software Mural acted as semantic diagram tools in this study. It has the basic technological function for concept mapping. For example, it allow student to add visual objects such as shapes, sticky notes, arrows, or picture that reflect their understanding of the specific learning topics. But also, it has some extra technological function for social interaction. For example, it allows multiple users to be online, editing the same concept map simultaneously – seeing one another's edits, and communicating through a chat window, make some comments to any visual objects. After examine the pre-post test data and the learning process data in the Mural in the CPS project, some findings were revealed for each question. These first-round findings will inform our next design iteration, to focus more on support the high level understanding of the learning topic meditated by semantic diagram tools.

Methods

Participants and study context

This study involved 25 female students in an urban high school in Canada. The participants were 7th grade taking regular high school health science classes. The teacher was a veteran of more than 10 years' experience working at this school, and an important member of the curriculum design team. A design-based research method was employed to design a learning project on Food and Nutrition in the WISE platform which orchestrating the

delivery of materials (including many suitable visualization tools) and collects all student learning process and result data for purposes of analysis.

Procedure

The CPS project took over four 70-minute class periods in this study. In the first class period, the teacher administered a 30-minutes pre-test and then make some introduction of the learning topic, the learning environment WISE, the semantic diagram tools Mural. In the second class period, teacher made some orientation learning activity, and then student logged in the Mural and finished the learning task 1 about *drawing the nutrient map*. The learning goal was to help student understand the function of each nutritional category. The 25 students were assigned into 6 groups, with each group responsible to make a collaborative concept map of one of the nutritional categories, based on their readings of relevant learning materials. We designed a "starter map" that included some of the basic nutritional elements (see Figure 1), and some starter links, such as "role within the body", and "supplied by what sources". This served to scaffold students in creating maps with relevant conceptual connections, focusing on the salient aspects of their food category.
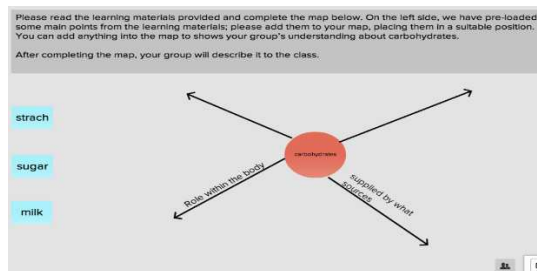

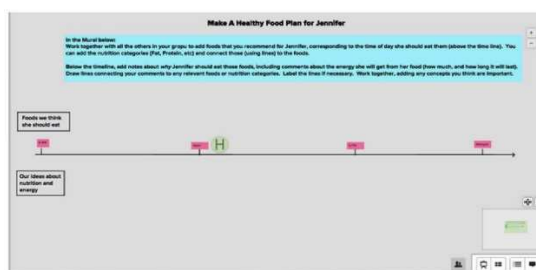Figure 1. The starter map in the learning task 1.

Figure 2. The starter map in the learning task 2.

In the third class period, firstly the teacher made some orientation learning activity. Then students logged in the Mural and finished the learning task 2. Compared with the learning task 1, the second one was more open-ended, which was about *How to make a healthy food plan*. They should think of a healthy food plan for a fictional student named Jennifer, who had been introduced earlier in the first class period. In this activity, new Mural groups were created with 6 students using a jigsaw pattern, where new groups of six students were assembled from member each of the previous groups. They were required to make a Mural map for "How to make a healthy food plan for Jennifer". Once again, a "starter map" was created (see Figure 2), this time in the form of a time line, from 6 AM to midnight, with a clear prompt in the area above the time line, "Foods we think Jennifer should eat" and below "our ideas about nutrition and energy". Students were asked to draw as many lines of connection between different foods, and ideas, as possible. In the four class period, the students were allowed to review their learning artifacts on the Mural map, and then made their conclusions of the CPS learning project. The post-test was finished in this period.

Data collection and analysis

Data from pre-tests and post-tests

In this study, student's cognitive development is measured in the identical paper-based tests before and after the CPS learning project. The 30-mins test included eight true-or-false items and three fill-in items that aimed to evaluate students' basic levels understanding of learning topics. The two open-ended items were used to evaluate students' high level understanding of the learning topic. For the eight true-or-false items and three fill-in items, "1" or "0" were recorded for the "correct" or "incorrect" answer. For the two open-ended items, a knowledge integration rubric (Linn, Lee, Tinker, Husic, & Chiu, 2006; Liu, Lee, Hofstetter, & Linn, 2008) was employed to code students' depth of understanding. The knowledge integration scores ranged from 0 to 4 and higher scores indicate more right and reasonable understanding about food and nutrition. Therefore students earned highest scores by showing their understanding of the relationship between food and nutrition.

Data from Mural

In this study, student's CPS engagement and interaction are evaluated from the Mural tracing data. Specifically, six episodes of group's learning tracing were collected from six Mural maps in the task 1. Four episodes of group's learning tracing were collected from four Mural maps in the task 2. The recoding form from Mural map recode the student's manipulation on the interface is [user's name A], [performance], [the visual object], [time]; [user's name B], [performance], [the visual object], [time]. Specifically, the "performance" includes deleted, added and

so on. The visual object includes text, image and arrow. Take the Figure 3 for example, Candice Chow add an image 11:18AM. And then Emily Zhang deleted a sticker at 11:18AM. While, Beral added a sticker at 11:18AM.

Each episode of Mural tracing data was firstly transferred into Excel in terms of the four fields, such as *what time, who, the manipulation times of the visual objects, what kind of the visual objects*(such as text, image and arrow). One episode of Mural tracing data is visualized according to the four fields, as shown in Figure 4. Based on that, the student's status of engagement and interaction can be analyzed. For student's CPS engagement in each task, it can be measured by the ratio of the certain student's manipulation times in the Mural interface to the whole group's total manipulation times in the Mural interface. For example, in the learning task 1, Jen manipulated 18 times on the Mural map, while her group managed 94 manipulation times. Therefore, Jen's engagement in learning task 1 is 18/94, namely 0.194. In the learning task 2, Jen manipulated 35 times on the Mural map, while Jen's group managed 243 times manipulation. Therefore, Jen's engagement in learning task 2 is 35/243, namely 0.144.For student's interaction in each task, it can be measured by the degree of centrality in the group, which is a simple tally of the number of people attached to each person. It can be calculate by the method of social network analysis by the social network analysis software, UCINET.

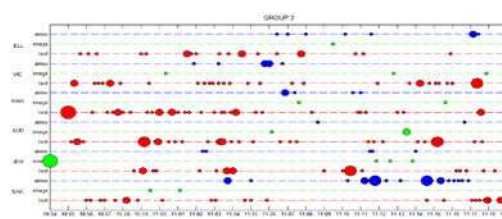Figure 3. The example of Mura tracing data.

Figure 4. The visual Mural tracing data in the time sequence.

Findings

Analysis of cognitive development

Table 1: Result of Student's Cognitive development

	Pre-test (N=19)		Post-test (N=19)	
	Mean	SD	Mean	SD
Basic understanding	0.57	0.17	0.79	0.13
High level understanding	0.50	0.15	0.46	0.17
Total understanding	1.07	0.27	1.25	0.23

Table 2: Result of Student's engagement and interaction

	Task1 (N=19)		Task2 (N=19)	
	Mean	SD	Mean	SD
CPS engagement	0.27	0.14	0.17	0.06
CPS interaction	0.25	0.11	0.18	0.05

A paired-sample t-test was employed to compare the students' pre-test and post-test scores to evaluate student's cognitive development during the CPS learning project. Means scores and standard deviations of learning gain and concept map items in the pre-test and post-test are present in Table 1. As shown in Table 1, there is significant different between pre-test and post-test scores in term of total understanding of the learning topic (t=-3.86, P=0.001<0.05). It means that student's cognitive development of the learning topic were improved after the CPS learning project. Besides, there is significant different between pre-test and post-test scores in terms of basic understanding of the learning topic (t=-6.89, P=0.000<0.05). This indicates that as a result of the intervention, students' conceptual understandings of food and nutrition have made some change for the better (e.g., of topics such as which foods are not nutritional, and which foods are in certain categories). However, no significant different exists between pre-test and post-test in terms of high level understanding (t=0.90, P=0.379>0.05), indicating that students' understanding of the relationships between food and nutrition did not improve. As a result of this project, students may not have formed deep understanding about the functions of different nutritional categories and the relationship among food, nutrition and body.

Analysis of CPS engagement and interaction in different tasks

A paired-sample t-test was employed to evaluate the student' CPS engagement and interaction in the two different tasks. Means scores and standard deviations of CPS engagement and interaction in task 1 and task 2 are present

in Table 2. As shown in Table 2, there is significant different between task1 and task 2 in term of CPS engagement (t=2.92, P=0.009<0.05) and CPS interaction (t=2.92, P=0.009<0.05). The students have engaged more in the task 1(M=0.27, SD=0.14) than they have in the task 2(M=0.17, SD=0.06). The students had more intensive interaction with each other in the task 1(M=0.25, SD=0.11) than they have in the task 2(M=0.18, SD=0.05). The task 1 is designed based on the basic knowledge of food and nutrition, while the task 2 is designed based on the intention of allowing students apply what they have learned to solving a real problem. In terms of complexity, task 2 is more complexity than task 1. Whether the complexity of learning task affect student's CPS engagement and interaction needs further investigate.

Analysis of the relationship between cognitive development and CPS engagement and interaction in different tasks

The path analysis by Amos software is employed to evaluate the relationship among cognitive development, CPS engagement and interactions in different tasks. Figure 5 portrays the result of this analysis. From the positive path coefficient of CPS interaction with cognitive development of the learning topic, it can be inferred that CPS interaction mediated by semantic diagram tools in the task 1 and task 2 make positive contribution to the student's cognitive development. It means that collaborative concept mapping individual's knowledge and understanding in the semantic diagram tools is a promising way for student's cognitive development. In the shared learning space, students can create the learning artifacts that present their knowledge and understanding of the learning topic, they can view the learning artifacts from their peers, which may stimulate them to think, or allow them to help the creators to make the learning artifacts better. On the other hand, for the negative path coefficient of the CPS engagement in the task 1 and task 2 with the cognitive development of the learning topic, it can be inferred that students may unconsciously manipulate the visual elements on the Mural map, which do not stimulate student's deep thinking or reflection. It uncovers our researchers that there should be some apparent and directed hints for students' manipulation of the visual elements to stimulate student's deep thinking.
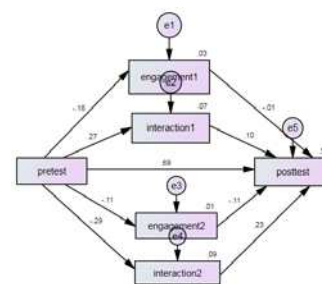

Figure 5. The result of path model.

Conclusions and implications

This paper reports the first stage of our study, which is to investigate the effect of cognitive development in the structured collaborative learning task mediated by the semantic diagram tools. An important outcome of the study is that integrating semantic diagram tool into the CPS learning task is a promising way to support student's cognitive development. In terms of analysis of the learning process, it could be found that, semantic diagram tool integrated the CPS learning task open a new window to investigate student's process status in the collaboration. The CPS interaction and CPS engagement mediated by semantic diagram tools in different task and their relationships with the cognitive development is explored in this study. How to take the advantage of semantic diagram tools to support the CPS interaction and engagement in structured CPS task in order to improve the deep learning should be the focus in the further study. What's more, those preliminary finding in this iteration could give some insight of future research, such as how to design suitable complexity learning task in CPS to support student's cognitive development; how to make student engage into the CPS learning task; how to support the deep thinking in the CPS mediated by semantic diagram tools and so on.

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