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Collaborative Problem-Solving Learning Supported by Semantic Diagram Tool: From the View of Technology Orchestrated into Learning Activity

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Abstract: Collaborative problem-solving learning (CPSL) refers to constructing knowledge and developing problem-solving abilities in the process of solving domain problems in a collaborative manner. Acting as a breakthrough of transforming traditional knowledge-centered instruction,CPSL hasreceived great attention by international researchers in education. Currently, how technology can be used to support and facilitate the process of collaborative problem-solvingremains the key research question. Therefore, our research team conducted a field study to investigate how technology can be really orchestrated into CPSL. A semantic diagram tool was integrated in primary school science class in Shanghai.This paperreports our second-round design-based research to answer two research questions: (1)How can the semantic diagram tool be integrated in classroom to support social interaction and collaborative problem solving; and (2)What are the major learning activities in the semantic diagram tool-supported CPSL. Video data collected in the whole CPSL project was analyzed using coding analysis method.The study reveals that,from technological perspective,semantic diagram tool can be combined with other technology to support the process of CPSL and,from instructional perspective, learning goal should extended and learning activities should be redesigned and refined according to the extended learning goal when semantic diagram tool is orchestrated into CPSL. Besides, the style of student activity and teacher's role can be changed in the semantic diagram tool-supported CPSL.

Keywords:CPSL; technology orchestrated into learning; instructional activity; classroom analysis

1. Introduction

Collaborativeproblem-solving learning (CPSL)refers to constructingknowledge anddeveloping problem-solving abilities in the process of solving domain problems in a collaborative manner (Stahl et al., 2006; Guet al., 2011). A large number of studies reveal that CPSL can improve student problem-solving skills, self-learning ability and deep understanding about knowledge (Lohman& Finkelstein 2000). However, some researchers found that in the process of collaborativeproblemsolving, students may encounter a variety of social and learning challenges, such as lack of structural knowledge, collaborative strategies and self-regulation abilities, to name but a few(Wegerif, 2006; Ge& Land, 2003; Jonassen et al., 1997). In the face of those challenges, this study aims to propose an innovative instructional design solution that integrates semantic diagram tool to support CPSL in the classroom.

2. Literature review

Previous studies often focus on two-fold ofinstructional interventionto supportCPSL thatis collaboration and problemsolving (Guet al., 2011; Ge& Land, 2003). However, CPSL is often lack of effective guidance or support in formal classroom teaching, especially in social and meta-cognitive aspects such as group development and self-regulation (Clark et al., 2012), making collaboration a mere formality, which in turn, may fail to reach the desired learning goals.Semantic diagram tool can be designed for supporting CPSL in an effective way. It makes use of graphics, images, animations and other visual elements to characterize the abstract knowledge, such as the concepts, principles and concept relations (Gu, 2013). In this study, a semantic diagram tool called Metafora platform was selected. Metafora platformis a web-based platform for science and math education.Itcan be used to visualize collaborative problem-solving process, promote collaboration and facilitate organizationof learning activities (Dragon et al., 2013). In this study we used two tools in the Metaforaplatform. One is called Planningtool that provides a set of icons calledVisual Language Cards to represent different steps in the collaborative problem-solving process so that learners can make working plans by using these cards. The other tool called LASAD is a dynamic concept-mapping tool for argumentation.

Although semantic diagram tool has many pedagogical advantages, it is difficult to integrate in classroom teaching effectively. Integrating technology in the process of teaching and learning requires a systematic adjustment by teachers which will bring additional teaching burden(Zhao & Frank, 2003). Also, there is a lack of domain-dependent pedagogical knowledge to align tool useinCPSL.It seems a gap between macro-level teaching guidance, such as lesson mode or teaching plans and micro-level instructional support in a particular teaching situation (Prieto et al., 2011a). Further, teachers should not only pay attention to the learning outcome of general teaching, but also make the appropriate instructional feedback and evaluation for different levels of collaborative learning process by using appropriate technology or teaching techniques (van Leeuwen et al., 2013). These bring challenges for teachers to organized teaching and learning activities through integrating technologiesin the classroom.

3. Methodology

3.1 Design-based research

Design-based research method (Brown, 1992) was adopted in this study to (1) analyze the practical problems in CPSL in the classroom; (2) propose and implement the instructional design that focuses onsemantic diagram tool-supported CPSL; and (3) to analyze the learning process of CPSL to understand the impact of technology integration in learning. This study reports the instructional design process and some preliminary findings of the second round DBR.

The first-round study reveals that the external pre-lecture affordances (such as collaborative skill training lesson before class begin,make a plan making for problem solving before learning task begin and teacher's instructive guidancebefore class begins and so on) for group's CPSL can promote group interaction, although well-organized so as to develop group's collaborative problem-solving skills of students remain in a surface level. Therefore, this second-round study focuses on how to give internalwithin-class affordance for the process of CPSL. in order tocan help student develop student's collaborative problem-solving learning competence is our main research goal in the second round study.

In this study we chose the Matefora platform as a semantic diagram toolto support the process of problem solving and collaboration, considering the tool can not only create learning space to motivate students to learn together, but also facilitate student reflectionon the learning process through visualization. Specifically, this study focuses on two-fold, that is how to design effective instructional strategies to integrate the semantic diagram tool in CPSL in the classroom and how the tool actually affords interactions and problem-solving process. Two research questions are proposed accordingly.

Question 1: *How can the semantic diagram tool be integrated in classroom to support social interaction and collaborative problem solving?*

Question2:*What are the major learning activities in the semantic diagram tool-supported CPSL?*

3.2Research context and participant

The study was conducted in aprimary school in Shanghai. Thescience teacher we collaborated with has more than 10 years ofteaching experience.Sheis open-minded in adopting innovative instructional approach and has positive attitude to apply ICT into classroom.Twenty-one students in the fourth gradewere randomly assigned into 5groups.The classroomwas equipped with PCs, Internet access, electronic projector and Metaforalearningplatform.

4 Instructional design and coding analysis

4.1. Instruction design framework

Orchestrating technology into learning activity is not a simple process of adding technology on learning. Technology should be integrated intothe classroom with a clear goal about how they will supportteaching and learning activities and how these activities fit into the overall curriculum (Baloian et al., 2000). Therefore, a holisticdesign for orchestrating semantic diagram tool in a CPSLsession is proposed by aligning tool functionality with learning goals and instructional strategies (see Fig. 1).

Continuing the research design in the first-round study, we designed four aspects research intervention strategies including group collaboration skills training (Dawes, 2004; Wegerif & Mansour, 2010), problem-solving plan making (Jonassen, 1997), learning tip offering to facilitate group discussion (Cho &Jonassen, 2002) and promotion of evidence-based discussion of students (Ge& Land, 2003; 2004) to achieve the learning goal of facilitating social interaction and developing problem-solving competence in CPSL.

As functionality of the semantic diagram tool is considered, LASAD can guide students in expressingand visualizingtheir ideas on a shared space in the real time. Therefore, we intent to use LASAD in two aspects, i.e., take rules and express attitude, to achieve the learning goal ofcollaborative problem-solvingskill development. Similarly, by using the representingicon in the Planning tool, students can make plans forthe problem-solving process. During the process of planmaking, discussion about which icon should be placed in a certain step for solving the problemis reflected in a generated conceptmap.Instructional strategies of question prompts and structuring the evidence-based argumentare adopted to supportstudentcollaborative problem-solving learning.

In order toorchestrate the intervention from both the research and technological perspectives, we designed instructional strategies in a behavioral level. We set up some warm-up activities at the beginning of the learning session in order to teach students how they can do collaborate problem solving. Also in the warm-up activities, we combined the exercises for collaborative skill and problem-solving skilldevelopment with those for getting familiar with Metafora platform. By doing the warm-up activities, we aim to reducethe workload ofusing the semantic diagram toolsin CPSL.After the warm-up activities, we intent to follow the problem-solving processof problemdefinition and analysis and organize learning activities by orchestrating the learning technology(i.e., LASAD and Planning tool).

4.2Learning contentand activity design

Through discussing with the science teacher, nutrition and digest from thescience textbook of Grade 4 was selected as the learning topic. Based on analysis the learning content of this unit, we designed five sequential learning points, namely, (1)classify the given foods based on the type of nutrition; (2)detect the main nutrition composition of given food; (3) discuss the function of certain type of nutrition; (4)survey and evaluate one's family's diet during one week; (5)develop a healthy diet plan for the family. Theinstructional design framework was then applied in the detailed design of each learning activityas shown in Table 1.

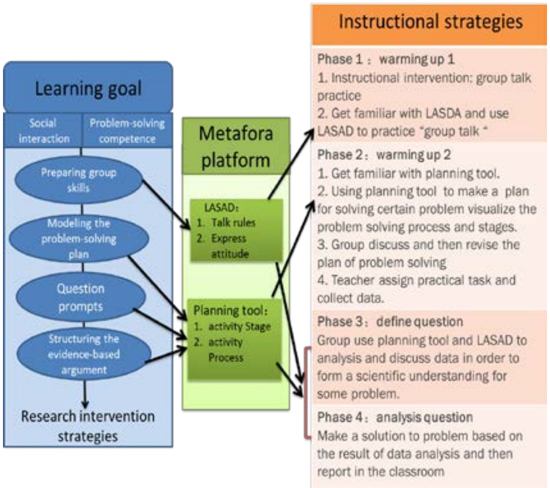

Figure 1. Instruction Design Framework

Table 1:Learning Content and Activity Design

Sess-ion	Pedagogical Objectives	Pedagogical activity	Tools
1	**Warming-up activity 1:** Understand the collaborative skills; Get familiar with the LASAD tool	Teacher introduces LASAD ; Student classify the rule of collaborative skill on the LASAD in order to make them understand and know collaborative skill	LASAD
	Point 1: Classify the given foods based on the type of nutrition	Ask students in group to confirm a criterion how to classify the food based on the data of nutrition ingredient； Let student in group express their ideas why they classify food according to the criterion on the LASAD	
2	**Warm-up activity 2:** Understand the process of solving-problem; Get familiar with the Planning tool	Introduction of Planning tool ； Explain student that we should first make a plan confirming the stage and process when solving a problem	Planning tool
	Point 2: detection the main nutrition composition of given food	Let student to make a plan for how to detection the starch in food on the Planning tool in advance; Make a experiment for detection the starch in the selected food; Ask students in group to reflect and remix their plan according to the real experiment	
	Hands-on activity for point 4	survey one's family's diet during one week	–
3	**Point 3:** discuss the function of certain type of nutrition	Assign different learning materials about introduction of nutrition and let every group to express their each understanding about the function of nutrition ingredient on the LASAD; Let every group report one's discussion result in the class level	LASAD;
4	**Point 4:** survey and evaluate one's family's diet during one week;	Each groups select one of diet which the member in group provided and evaluate it based on the result of shared activity about understanding the function of certain type of nutrition on the LASAD;	LASAD;
	Point 5: Develop a healthy diet plan for family	Based on the evaluation every group discuss in group how to develop a healthy diet plan by using of Planning tool and LASAD.	LASAD; Planning tool

4.3 Data collection and analysis method

Inorder to answer the two research questions, we analyze the whole class videos collected in this study using coding analysis approach.The video data recorded the whole class activity which lasted four sessions (35 minutespersession).In order to understand what real happened in theclassroom, our research team members worked together to transcribe the video record into text according to what teacher said word by word and what the students did in the class.After finishing the transcription, we adoptedtwo types of coding scheme to analyze the text data to answer those two research questions.

Table2: Coding Scheme Example for the Whole Class Activities

Time	Role	Discussion content	Label the activity	Coding the meaning of activity
13:55	T	Today we will learning something about food and nutrition(wrote in the blackboard). Firstly, I want to ask you what question you would like to ask when you see these words?	Teacher's activity	5.Intuduce learning topic
	S1	Which food do it point to?		
	S2	Which nutrition do food contain?		
	T	Ok. Which nutrition do food contain? It is means that different food contain different nutrition. Today, that is the content we are going to research.		
15:03	T	Next I will assign a table into every group which show names and amount different types nutrition of food. I hope when your group get the table, read it seriously and tell me what you find out. ok? After every group finish their discussion, I will let you report your finding group by group.	Teacher's activity	6.distribute learning materials and assign group discussion task
15:10	G	Start to discussion	Student's activity	7. Group discussion
19:02	G	End up discussion		

To answer the first research question ofhow to integrate semantic tool into instructional activity in the collaborative problem-solving learning, we should depicting the context of how to orchestrate technology into learning activity. Because every instructional activity with single goal can be viewed as a unit distinguished from other instruction activity(Prieto et al., 2011b), we use a complete undivided learning activity in the classroom as a coding unit and then make a qualitative coding scheme for the class video section which was shown a certain instructional meaning from the teacher and student activity perspective. The scheme example is shown in Table 2.

Table 3: Coding Scheme of Teacher's Activity, Students' Activity and Technology

Role	Activity items	Meaning of item	Example of activity	Coding picture
Teacher's activity	explain	Transmits necessary knowledge to the students	1. Intruduce group rule; 29. Review how to make a plan by planning tool	○
	support	Give certain or support for learning activity;	6.Distribute materials and assign group task 15.Show experiment tool	△
	evaluate	the results of tasks are evaluated	20. Conclusion for experiment	⬡
Student's activity	Discuss	discuss learning task	2. Discuss group rules 10. brainstorming	□
	Report	report learning task	3.Group report	⬠
	other	Other student's activity	13.Observe experiment firstly	⏢
technology	Technological support	technology used in a certain learning task	LASAD was used in the activity 2	

To answer the second research question of what the major learning activities are in the semantic diagram tool-supported CPSL, wecoded learning activities from the perspective of teacher and student activities. The analysis of classroom activity integrated with technology should reflected the interactionsamong teacher, students andtechnology because technology integrated into instruction and learning process not only bring new learning material into classroom but also contribute to the transformation of learning style, instructional method and interaction way between teacher and student (Gu, 2004). Specifically, we distinguished three types of teacher activity(explanation, support and assessment) and three types of student activities (group discussion, group report and others) according to the characteristic of this study. The coding schemeis adapted based on the scheme designed byPrieto et al.(2011b) and shown in Table3.

4.4 Results and discussion

Question 1:How can the semantic diagram tool be integrated in classroom to support social interaction and collaborative problem solving?

According to the rule of scheme example in Table 2, there are 35 units of instructional activities codedfrom the class video. Then we made a diagram of teacher and student activities and technologies used in the class. The x-axis is the time lineand the y-axis is the learning goals. The visualized result of instructional activity in the whole learning project is shown in Fig. 2. The grey box in Fig. 2representing certain learning activity indicates the step in which technology was used.

After analyzing the Fig.2, three findings are obtained.First, we can find in the process of orchestrating semantic diagram tool into learningactivities, the tool combines with other traditional learning technology, such as focused materials, designed worksheetand prepared laboratory itemsgive support for collaborative problem-solving process from a technological perspective. Therefore, we believe that traditional learning technology and digital learning technology can coexist in the class to support the learning process. To some extent, the findings infer that different learning activities with certain goals should be supported by different learning technologies, that is,single learning technology cannot play the whole role in support of the whole class activities.Second, comparing the traditional learning goal set in advance with those achieved in the study, we can find that in the process of orchestrating semantic diagram tool into learning activities, learning goals are extended. We held thatthe extension of learning goals can offer learning technology the integrated space and value to orchestrate into the learning process. Third, compared with the traditional instructional design without using semantic tool, we can see that learning activitiesare redesigned and refined according to the extended learning goal. Specifically,teacher should transform instructional philosophy of what to teach into how student learn and how we can use technology to support the learning processin practice which conforms to the student-centered instructional idea.

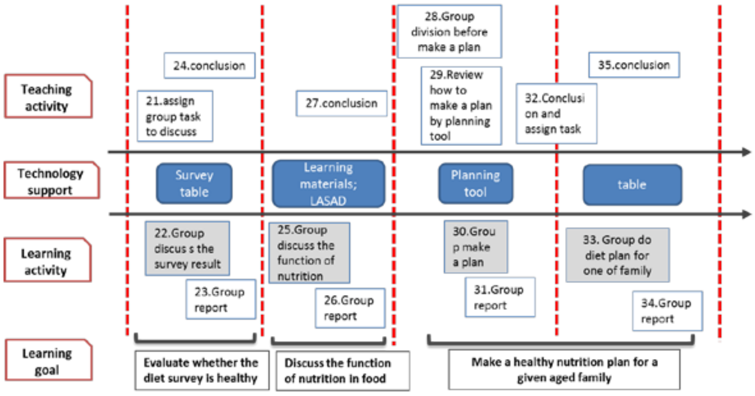

Figure2.A Part of The Diagram for the Whole Class Activities
Based on the Coding Scheme in Table 2

Question 2: *What are the major learning activities in the semantic diagram tool-supported CPSL?*

Based on the metaphor of orchestration(Fischer&Dillenbourg, 2006), we coded the video data again into the transition diagram of instructional activity according to the type of teacher and studentactivity, the type of interaction(in the individual level, in the group level and in the class level) and the use of technology to visualize clearly the structure of how technology can be orchestrated into CPSL process. The coding result is shown in Figure 3.

As can be seen in Figure3, group report activity and group communication activitytook up 11/35(31%) and 8/35(23%) of all classroom activities, respectively. These two types of student-centered learning activities took up over one half(19/35) in all. Compared with the traditional teacher-centered lecturing approach, there was obvious transfer towards student-centered learning in this semantic diagram tool-supported CPSL. Further within all teacher-centered activities,supportactivitiestook up 7/16(43.75%), whereasassessmentand explanationactivities took up6/16(37.5%) and3/16(18.75%).The findings reveal thatin the collaborative problem-solving learning, the teacher played a role of learning facilitator rather than knowledge transmitter or classroom dominator.And the unique function of technology orchestrated into learning process is to promote and to catalyze the change of learning activity and teacher's role in the class.

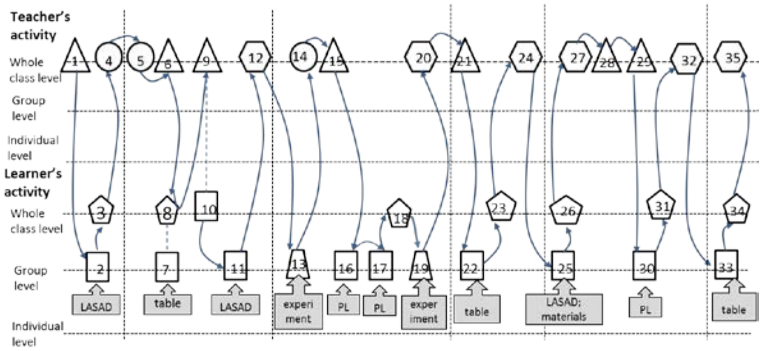

Figure 3.The Diagram for the Whole Class Activities
Based on the Coding Scheme in Table 3

5. Conclusion

In this paper, a whole class case of orchestrating technology to support the process of CPSL is reportedfocusing on the instructional design and coding analysis of learning processbased on the design-based research method. From the macro-level perspective, we held that learning technology orchestrated into CPSLis a complex progress, which contains the technological design and implementation, learning activity design and organization and content analysis of learning process in a real setting.From the micro-level perspective, we concluded that, in order to support the process of CPSL, technology should be orchestrated into learning with the goal of developing domain-knowledge and collaborative problem-solving competencethat is to offer learning technology an integrated space and value in the learning process and organize learning activitiesin line with instructional philosophy of how students learn and how we can use technology to support the learning processin real practice.

This study focuses on how to orchestratesemantic diagram tool to support CPSL from the viewpoint that technology can be effectively orchestratedin classroomlearning activities. However, whether the semantic diagram tool-supported CPSL can produce positive learning outcome compared with traditional lecturing and how this innovative instructional design actuallyaffect student learning behavior change remain unknown. Therefore, further research is required onthese questions.

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Referecnce

Brown, A. L. (1992). Design experiments: Theoretical and methodological challenges in creating complex interventions in classroom settings. *The journal of the learning sciences*, 2(2), 141-178.

Baloian, N. A., Pino, J. A., & Hoppe, H. U. (2000).*A teaching/learning approach to CSCL*. Paper presented at the System Sciences, *Paper presented at the 33rd Annual Hawaii International Conference*.

Cho, K. L., &Jonassen, D. H. (2002).The effects of argumentation scaffolds on argumentation and problem solving. *Educational Technology Research and Development,* 50(3), 5–22.

Clark, R. E., Kirschner, P. A.,&Sweller, J. (2012). Putting Students on the Path to Learning--The Case for Fully Guided Instruction. *American Educator*, 6-11.

Dawes, L. (2004). Talk and Learning in Classroom Science. *International Journal of Science Education*, 26 (6) 677–695.

Dragon, T., Mavrikis, M., McLaren, B., Harrer, A., Kynigos, C., & Wegerif, R., et al. (2013).Metafora: A web-based platform for learning to learn together in science and mathematics.*IEEE Transactions On Learning Technologies*.

Fischer, F., &Dillenbourg, P. (2006).Challenges of orchestrating computer-supported collaborative learning. *Paper presented at the 87th Annual Meeting of the American Educational Research Association (AERA),* San Francisco, California, USA.

Ge, X., & Land, S. (2003). Scaffolding students’ problem-solving processes in an ill-structured task using question prompts and peer interactions. *Educational Technology*, *Research and Development*, 51(1), 21–38.

Ge, X., & Land, S. (2004). A conceptual framework for scaffolding III-structured problem-solving processes using question prompts and peer interactions. *Educational Technology Research and Development,* 52(2), 5-22

Gu, X. Q. (2013). The theory and practice research on presenting and modeling of visual knowledge by semantic diagram tool. *The research program application report funded by the National Science Education "1025" planning*.(in Chinese)

Gu, X. Q., & Wang, W. (2004). The exploration research on analysis of classroom activity supporting for teacher’s professional development.*China Educational Technology*,7:18-21. (in Chinese)

Gu, X. Q., Guo, X. F., & Cai, H. Y. (2011). Research on Leaning in a Scientific Way: Connecting the Theory and Practice of CSCL. *Modern Distance Education Research*. (05), 15-22. (in Chinese)

Jonassen, D. H. (1997). Instructional design models for well-structured and III-structured problem-solving learning outcomes. *Educational Technology Research and Development*, 45(1), 65–94.

Lohman, M.C. & Finkelstein, M. (2000).Designing groups in problem-based learning to promote problem-solving skill and self-directedness. *Instructional Science*, 28, 291 – 307.

Prieto, L. P., Villagrá-Sobrino, S., Dimitriadis, Y., Schank, P., Penuel, W.&DeBarger, A. H. (2011a). Mind the gaps: Using patterns to change everyday classroom practice towards contingent CSCL teaching. *Paper presented at the 9th International Conference of Computer-Supported Collaborative Learning*, Rhodes, Greece.

Prieto, L. P., Villagrá-Sobrino, S., Jorrín-Abellán, I. M., Martínez-Monés, A., &Dimitriadis, Y. (2011b). Recurrent routines: Analyzing and supporting orchestration in technology-enhanced primary classrooms. *Computers & Education*, 57(1), 1214-1227.

Stahl, G., Koschmann, T., &Suthers, D. (2006). Computer-supported collaborative learning: An historical perspective. In R. K. Sawyer (Ed.), *Cambridge handbook of the learning sciences*. (pp. 409-426). Cambridge, UK: Cambridge University Press.

Van Leeuwen, A., Janssen, J., Erkens, G., &Brekelmans, M. (2013). Teacher interventions in a synchronous, co-located CSCL setting: Analyzing focus, means, and temporality. *Computers in Human Behavior*, 29(4), 1377-1386.

Wegerif, R. (2006). A dialogical understanding of the relationship between CSCL and teaching thinking skills. *International Journal of Computer-supported Collaborative Learning (ijCSCL)*, 1(1), 143–157.

Wegerif, R., & Mansour, N. (2010).A dialogic approach to technology-enhanced education for the global knowledge society.InKhine, M. S. &Saleh, I. M. (Eds). *New Science of Learning: Cognition, Computers and Collaboration in Education*(pp 325-340). New York: Springer.

Zhao, Y., & Frank, K. A. (2003). Factors affecting technology uses in schools: An ecological perspective. *American educational research journal*, 40(4), 807-840.