Collaborative Knowledge Construction Using Concept Maps for Cross-cultural Communication

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***Abstract*— This paper reports on the results of experiments with our concept map tool developed for collaborative knowledge construction in cross-cultural communication. The purpose of this study is to contribute toward the improvement of synchronous-interactive (real time-two way) international distance education, which we believe will significantly develop within our globalizing educational field. Collaborative knowledge construction is the process in which all the participants in a learner community can equally integrate and share their knowledge. For this purpose, it is essential for them to understand the other members' recognition as well as their contributions. Visualization of these reactions is vital for successful knowledge construction. In cross-cultural communication in particular, it is of great importance to be able to visualize them since the perception of participants tends to be limited. Our concept map tool has been developed in order to visualize recognition and contribution for successful collaborative knowledge construction. The results of our four experiments indicate that our tool is (i) useful for sharing the knowledge of each participant, (ii) useful for visualizing the knowledge and contribution of each participant within the discussion in order to construct collaborative knowledge, and (iii) more effective than other traditional tools, such as chat, for cross-cultural communication.**

Keywords-CSCL; concept map; collaborative knowledge construction; cross-cultural communication

I. INTRODUCTION

Current information and communication technologies make it possible to communicate face-to-face in international settings using high-quality video conferencing systems [1][2]. Future development requires tools for supporting integration of knowledge through communication. Support tools for sharing and visualizing knowledge of all participants are useful for this purpose. Concept maps are tools for visualizing participant knowledge [3], and there has been recent research related to using concept maps for collaborative knowledge construction [4]. We developed a collaboration tool for knowledge integration and sharing in cross-cultural communication using a participant-constructed collaborative concept map. This paper reports the results of experiments with our tool.

Section II introduces a progress report of this and peripheral research. Section III describes our concept map tool. Section IV describes four experiments using our tool. In that section, Subsection A describes results of questionnaires to participants in the first experiment. In Subsection B, individual concept maps are constructed beforehand, and the maps are compared with concept maps created during collaborative knowledge construction. From the results, we discuss how preexisting individual knowledge was used and how knowledge structures changed through collaborative construction. Based on those results, we discuss the relationship between individual concept maps and collaborative concept maps. In Subsection C, participants were required to construct concept maps individually after constructing concept maps collaboratively. Based on those results, we evaluate whether shared collaborative knowledge was retained. The effectiveness of this tool is furthermore evaluated by comparison with a group that performed a similar activity using a chat system and a live whiteboard chat system. We also conducted an experiment to evaluate whether Chinese students and a cross-cultural group (a mixed group of Japanese and Chinese students) used this tool effectively, and Subsection D reports the results of that experiment. Section V presents our conclusions.

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The four above-mentioned experiments confirmed the following:

–Participants felt that our tool was useful for knowledge sharing (discussion structuring and visualization).
–Participants felt the necessity of knowledge and contributions from other participants through using the visualization function in our tool.
–Collaborative knowledge construction using a concept map requires participants to use their individual knowledge and reconstruct their knowledge structure.
–Our tool is more effective in collaborative knowledge construction than other traditional tools, such as chat and shared whiteboard chat.
–Our tool is also useful in cross-cultural communication.

II. PROJECT PROGRESS AND LITERATURE REVIEW

Our project realized several support tools. The tools connected classes in four Asian countries (Japan, Korea, China, and Thailand) for cross-cultural communication in a Teaching English as a Foreign Language class. An unsolved problem in the practice of synchronous (real-time) and symmetric (two-way) communication using high-quality video conferencing systems [1][2] is that productive growth requires that all participants recognize what is actually being achieved during their interaction. In this context, a visualization tool is useful to recognize and share the achievements of each participant. We, therefore, developed a visualization tool that incorporates a concept map to share collaborative knowledge construction.

Related literature reports on various tools for knowledge construction that have positive effects. Analysis of conflict in a jigsaw-type class has been performed in regards to collaborative knowledge construction [5]. In this research, each participant received different knowledge and then constructs collaborate knowledge while they taught their knowledge to each other. This study facilitates knowledge collaboration using a jigsaw-type method with MS Word as a tool for collaboration. Collaborative learning spaces such as wikis and their supportive nature in motivating participants to construct knowledge have also been examined [6].

A tool for visualizing and sharing knowledge is useful for collaborative knowledge construction. Roth & Roychoudhury proposed that concept maps are useful for the activity by the following three factors: tools for social thinking, conscription devices, and inscription methods [4].

Various collaborative concept map creation tools have been developed. KMap uses multimedia content for collaborative concept mapping [7], sharing concept maps via LAN with multimedia content such as text, audio, and video. Participants use other concept maps that are not edited,, making it an asynchronous tool. In our context, synchronous communication is important. CmapTools is a tool for collaborative concept mapping for synchronous and asynchronous communication [8]. This tool has various communication functions and Knowledge Soup for sharing propositions, deriving propositions from concept mapping. These various functions enable participants to conduct various activities.

In our project, we developed the tool focused on visualization of participant contributions to heighten knowledge sharing and collaborative knowledge construction and evaluated the tool in synchronous cross-cultural communication in four experiments.

III. SYSTEM DESIGN

We developed a tool for collaborative knowledge construction using concept maps (Figure 1). Our tool has the following functions for collaborative knowledge construction and visualization of participant contributions and discussion structure:

a. Real-time Chat
b. Adding a Keyword (in a different color for each proposal)
c. Moving a Keyword
d. Adding a Link
e. Adding a Linking Phrase (in a different color for each proposal)

Functions (b) through (e) are used for collaboratively constructing concept maps. Color-coding the proposals allows participants to recognize the contributions of others. Individual proposals are clearly indicated by colored keywords. Participants can recognize their own contributions and see them as part of the entire class. When participants depend solely on others, there is no indicator of their contribution in this colored map. Moreover, interaction is facilitated because visualization of contributions promotes the feeling that participants were part of a face-to-face interaction.

Participants join in a discussion through chat and by proposing keywords (a node in the concept map). Keywords can be moved anywhere, and linking phrases can link between them. If a user adds a keyword, this appears in the upper-left corner of the window labeled “Start”. Users can move added keywords and add links between them. Linking phrases can be added at the top left.

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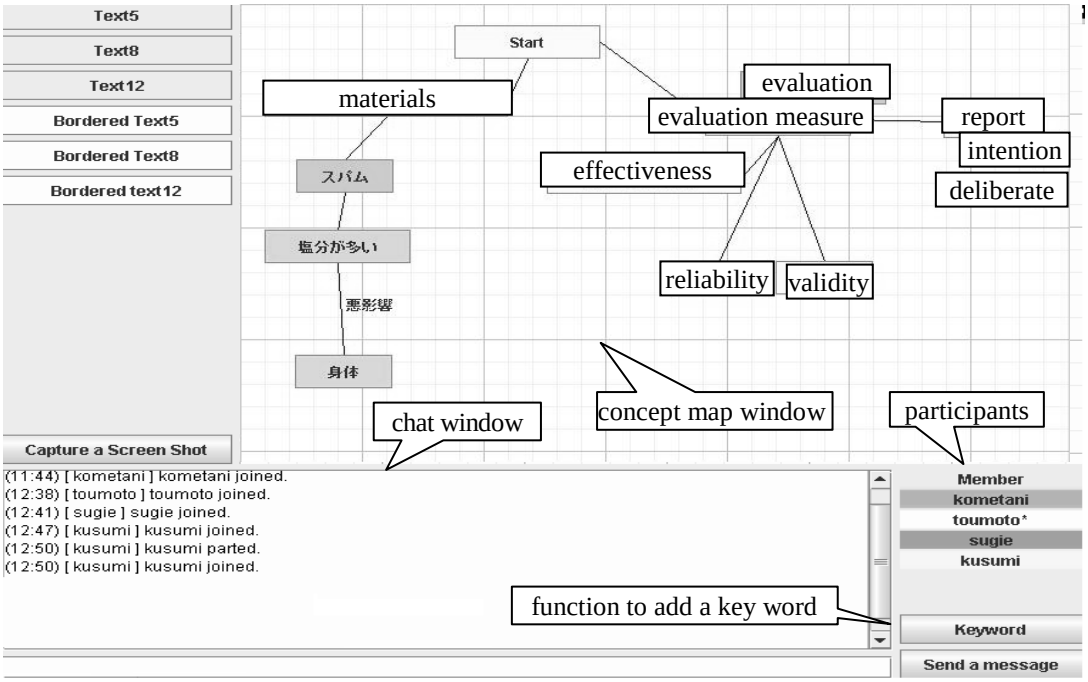

Figure 1. Interface of the collaborative knowledge construction tool

IV. EXPERIMENTS

A. First experiment

1) Purpose

The first experiment was designed to confirm the following:

–Participants feel that our tool is useful for knowledge sharing (discussion structuring and visualization).
–Participants recognize the necessity of knowledge and contributions from other participants through using the visualization function in our tool.

2) Method

The experiment was performed on July 13, 2009 from 13:00 to 14:00 at Hokkaido University, Waseda University, and Tokyo University of Science in Japan. Three student participants, one from each university, joined the experiment. The author played the role of mentor in only this experiment. The concept map played a supplementary function for the main focus, an online discussion on how to create a comfortable laboratory. The discussion was conducted in Japanese [9].

3) Results and Discussion

After the experiment, a questionnaire was distributed to the participants. They awarded a numerical score for their reaction based on a modified five-point Likert scale:

5 "Chat and concept map" is much better,
4 "Chat and concept map" is better,
3 No difference,
2 "Chat only" is better, and
1 "Chat only" is much better.

Table 1 shows participant preferences. In particular, items (2) and (3) obtained the highest score of 5. Participants indicated that the concept map was very useful in the online discussion as an aid to seeing the overall structure of the discussion and, at the same time, their own and others' contributions. Though these results might be expected since use of the tool is optional, participants would prefer "Chat only" if they found this function detracting due to the time and energy demands of constructing concept maps while chatting. The results, however, showed a strong preference for "Chat and concept map." We take this as indicating that constructing a collaborative concept map with our tool enabled them to better gather, share and integrate their knowledge. Thus, both goals were achieved.

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TABLE I. RESULTS OF QUESTIONNAIRES

Questionnaire Item	Average Score
(1) I recognized my contribution to the discussion	4.7
(2) I recognized others' contributions to the discussion	5.0
(3) I understood the structure of the discussion	5.0
(4) I felt that others and I had a common understanding	4.3
(5) I recognized the distance of my keyword from the discussion theme	4.3
(6) I was able to generally reflect upon the discussion	4.3

B. Second experiment

1) Purpose

The second experiment was designed to confirm the following:

–Collaborative knowledge construction using a concept map requires participants to use their individual knowledge and reconstruct their knowledge structure.

2) Method

The experiment was performed on November 24, 2009 from 17:00 to 19:00 with the same participants as the first experiment. In this experiment, however, the author did not participate as a mentor. The online discussion topic was ecolonomics. This discussion was also conducted in Japanese.

Participants were first given the theme, and were given fifteen minutes to individually construct concept maps without discussion. Next, they constructed a concept map as in the first experiment through chat discussion and concept map creation. Afterwards, we required them to correlate nodes and links between the individual concept maps and the collaborative concept map shown in Figure 2. We allowed them to note correlations even if wordings differed between individual and collaborative concept maps when they felt the same meaning was indicated. For example, in the case of participant B, he used the node "fulfilling research" in the pre-constructed concept map and also proposed it in collaborative concept map, so he correlated them. In the collaborative concept map, the node "laboratory's space" was proposed by participant C but participant B had used it also in his pre-constructed map, and thus he correlated them. In addition, the node "criticism from everyone (around)" was proposed by participant A and the node "opinion from everyone (around)" was proposed by participant B. Although these words were different, participant B felt that they had same meaning and correlated them. Because he made a link between the nodes "fulfilling laboratory's life" and "fulfilling research" in both maps, he correlated them. Moreover, in the pre-constructed map, he made a link between "fulfilling research" and "thinking power". Although the link was not proposed directly in the collaborative concept map, he thought that a semantic link existed between "thinking power" and "research process". He saw "research process" as intermediate between "fulfilling research" and "thinking power" so considered it an advanced node, and thus correlated them.

3) Results and Discussion

Table 2 shows the results of the correlations. A high proportion of nodes were shared between both individual and collaborative concept maps. This result suggests that each participant's knowledge was used in the collaborative concept map, and that participant knowledge was integrated and expanded. There was, however, a low proportion of common links. These results indicate that knowledge relations were not maintained and new relations were generated when construct concept maps were collaboratively generated. Knowledge structures of each participant, therefore, were rebuilt because the relations between nodes are the knowledge structure of individual participants. This suggests that collaborative concept mapping using our tool promotes integration and expansion of knowledge, and also generates new knowledge structures.

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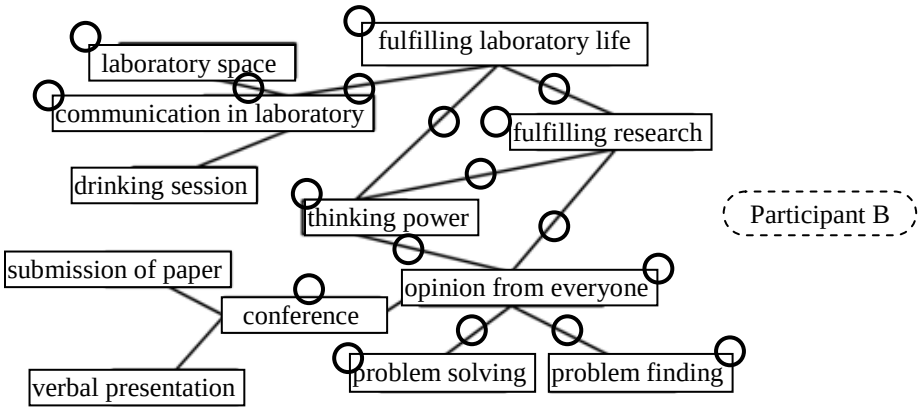
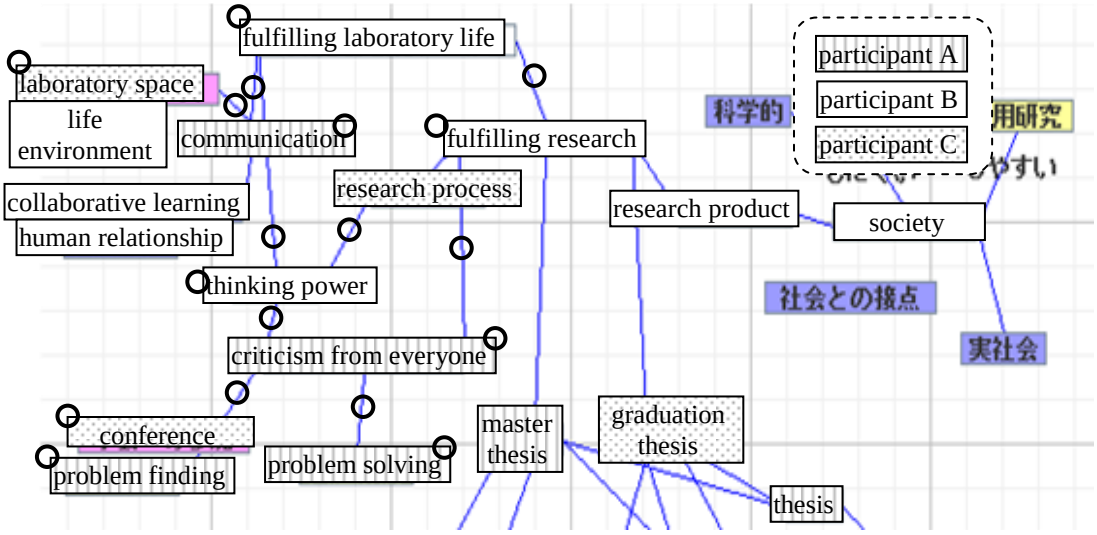


(a) An individual concept map pre-constructed by a participant



(b) Collaborative knowledge constructed by all participants through discussion

Figure 2. Correlations of nodes and links

TABLE II. THE NUMBERS AND PROPORTIONS FOR PRE-CONCEPT MAP AND COLLABORATIVE CONCEPT MAP

		Number used in pre map	Number used in both maps	Proportion
Participant A	**Node**	25	11	**44%**
	Link	26	4	15%
Participant B	**Node**	42	31	**74%**
	Link	48	16	33%
Participant C	**Node**	14	11	**76%**
	Link	22	7	32%
Average	**Node**	27	17.7	**65%**
	Link	32	9	27%

C. Third experiment

1) Purpose

The third experiment sought to confirm the following:

–Our tool is more effective in collaborative knowledge construction than other tools, such as chat and live whiteboard chat.

2) Method

This experiment was performed twice using two different themes (Theme 1: “Why one should work in society”; Theme 2: “How to turn one million dollars into ten million dollars in five years”) on August 20, 2010, from 13:00 to 15:00, and on August 22, 2010, from 13:00 to 15:00, by participants from Waseda University and Tokyo

University of Science in Japan. Nine students from each university joined the experiment. We formed three groups consisting of three participants in each of a concept map group, a chat group, and a live whiteboard chat (LWC) group. The discussion was conducted in Japanese.

Participants in the concept map group conducted their conversation using our tool, and then created individual concept maps indicating their post-discussion knowledge construction. Participants in the chat group conducted their discussion using a chat system, and then described their post-discussion knowledge construction as a freeform description. Participants in the LWC group conducted their discussion using an LWC system with a shared canvas, and then described their post-discussion knowledge construction as a freeform description. Chat group and LBW group participants were allowed to convert their chat logs and post-discussion descriptions into concept maps after we explained to them what a concept map is. Finally, we asked each group to correlate concepts as in the second experiment.

3) Results and Discussion

Table 3 shows the number of nodes and links used by individual post-discussion concept maps, the match numbers and rates of nodes and links, and the usage rate in both post-discussion concept maps and collaborative concept maps. Table 3 confirms the following. The concept map group's collaborative concept map was big, and the match rate between collaborative concept maps and individual post-discussion maps was high. In the chat and LWC groups, collaborative concept maps (collaborative knowledge) were small, and the match rate between collaborative concept maps and individual post-discussion individual maps was low.

TABLE III. RELATIONSHIP BETWEEN COLLABORATIVE KNOWLEDGE AND POST-DISCUSSION INDIVIDUAL KNOWLEDGE.

Average number and rate		Theme 1		Theme 2	
		Number used in both maps	Proportion	Number used in both maps	Proportion
Concept map group	Node	**20.3**	**98.4%**	**24.3**	**95.6%**
	Link	**21.7**	**81.6%**	**25.0**	**79.8%**
Chat group	Node	5.0	55.2%	4.7	59.5%
	Link	1.7	20.1%	2.3	27.0%
LWC group	Node	3.7	72.2%	3.3	28.5%
	Link	1.3	41.9%	1.0	6.5%

These results suggest that only the group using our tool for concept map construction was able to effectively construct collaborative knowledge. These results also suggest that our tool enabled sharing and retention of collaborative knowledge.

D. Fourth experiment

1) Purpose

The fourth experiment aimed to confirm the following:

–Our tool is useful in cross-cultural communication.

2) Method

This experiment was conducted twice. In the first iteration, two groups of four Japanese and four Chinese students, respectively, had a chat discussion in their native tongues. They next had a discussion using our tool, and then answered a questionnaire. Finally, participants were reformed into cross-cultural groups of two Japanese and two Chinese students each. Those groups held discussions in English using chat only and then using our tool, after which they answered questionnaires.

3) Results and Discussion

Participants assigned numerical scores to evaluate their reaction based on a modified five-point Likert scale:

5 "Chat and concept map" is much better,
4 "Chat and concept map" is better,
3 No difference,
2 "Chat only" is better, and
1 "Chat only" is much better.

The results shown in Table 4 do not indicate significant differences between the three groups, indicating that the tool can be used similarly in discussions among both Japanese and Chinese students, as well as with cross-cultural groups.

TABLE IV. RESULTS OF QUESTIONNAIRES

Questionnaire item	Japanese Students	Chinese Students	Cross-Cultural
(1) I recognized my contribution to the discussion	3.75	4.0	3.5
(2) I recognized other's contributions to the discussion	3.75	4.0	3.5
(3) I understood the structure of the discussion	5.0	5.0	4.75
(4) I felt that others and I had a common understanding	4.25	3.25	3.5

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V. CONCLUSIONS AND FUTHER CONSIDERATIONS

This paper described how a concept map can be used in order to show an on-going discussion structuring and visualization. The results show that the system can be used for the purpose of reflecting upon the collaborative knowledge construction through the visualization of participant contributions and discussion structure.

The following were confirmed through the four experiments described above: 1) Participants seem to feel that our tool is useful for the sharing of knowledge (discussion structuring and visualization). 2) Using the visualization function in our tool, participants can see the contributed knowledge of others and the necessity of contribution (contribution visualization). 3) Collaborative knowledge construction using a concept map requires that participants use individual knowledge and reconstruct their own knowledge structures. 4) Our tool is more effective than other traditional tools, such as chat, and is also useful in cross-cultural communication.

Since there were some limitations in our experiment, however, future work will be focused on finding solutions to the following issues: 1) how to increase the number of participants so that this system can be incorporated into regular distance classes, 2) conducting trials in an international multi point situation which will involve students from different backgrounds to meet global educational situations, and 3) how to integrate this system with the synchronous-symmetrical video conferencing system of our previous work, which was developed as a cross-cultural language class [10]. In terms of functions, we plan to further develop a system that can provide more nodes and links to give depth to expressions in discussion. We plan to further develop a system that allows all participants to construct the concept map without any assistance from a mentor.

Our globalizing world needs more borderless, cross-cultural, collaborative communication in every social field, including education. International distance education that is synchronous and interactive is not only applicable to transmission of information for classroom lectures and discussion, but could more broadly help participants experience concept construction in the distance communication environment. Technological contributions such as the system introduced in this paper will contribute to achieving these goals, adding a new dimension to collaborative learning.

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