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Knowledge Propagation in Practical Use of Kit-Build Concept Map System in Classroom Group Work for Knowledge Sharing

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Abstract: This study proposes a design of class in which learners collaboratively organize and share what they learned in lessons. Concept mapping is a well-known technique that can help students to create visual representations of the structure of their understanding. This study uses a special kind of concept mapping for knowledge sharing, Kit-Build method. The characteristic of this method is to provide parts to build a concept map for learners. A teacher makes the parts and thus he/she can manage what students should learn and assesses answers automatically. This paper reports the result of classes conducted with Kit-Build concept map and analyzed the knowledge propagation in the collaborative learning. Through collaborative Kit-Build mapping among students the concordance rate of learner maps went up and the score of the maps improved. This indicates that students have shared and corrected their knowledge through the activity. In this study the teacher could realize the understanding of students and taught them what did not understand well based on the feedback of KB map system.

Keywords: kit-build, concept map, collaborative learning

1. Introduction

Development of creativity is one of the important goals in education (Griffin, 2012). On the other hand, Jonassen (Jonassen, 1992) and Scardamalia et al. (Scardamalia, 2012) point out a stage prior to develop creativity. Jonassen defines three stages of knowledge acquisition; introductory, advanced, and expert. At the introductory stage, learners acquire the knowledge that is in well-structured domains and it has only a correct answer for a question. At the advanced stage, learners acquire more advanced knowledge, that is in ill-structured domain and it could have various answers for one question. Expertise is the final stage where experts have more internally coherent and more richly interconnected knowledge structures. Scardamalia specifies two levels of knowledge construction; entry and high level. These levels are the equivalent of Jonassen's introductory and advanced stage, respectively.

This study focuses on knowledge construction for the basis of creative tasks. The aim of this study is to design learning activities in classroom intended to encourage knowledge construction prior to development of creativity. In this study, according to Jonassen and Scardamalia et al., the requirements for the activities are that students can build their own knowledge inductively and check correctness of it in interaction with other students. They need to correct their knowledge as necessary and finally they share correct knowledge. This shared and correct knowledge is expected to lead their next activities for development of creativity. From the viewpoint of the definition of collaborative learning by Dillenbourg (Dillenbourg, 1999) the required elements are symmetry of action and status of students, interaction among them and inductive thinking.

To satisfy the requirement this study adopts collaborative learning with Kit-Build concept map (Yamasaki, 2010). Kit-Build concept map is a kind of closed concept map construction system in which learners make concept maps from parts provided from a teacher. Although this is similar to Expert skeleton concept map, the difference from it is that Kit-Build concept map requires learners to completely rebuild a concept map from fragmented pieces of concepts and links. Learners relive the consideration of relation among concepts in the target domain. This method is also effective in diagnosis of learners' understanding. The concept map represents the structure of what the teacher want

students to understand. A learner's understanding can be evaluated as the concordance rate between a map made by the learner and one made by the teacher. General concept mapping uses open system in which there is no restrictions to build concept maps and constructors use any nodes and links. In this case, it is difficult to diagnose concept maps (Herl, 1999). There are studies show the effectiveness of Kit-Build concept map in evaluation of and feedback to learners based on it (Sugihara, 2012) (Yoshida, 2013).

Maldonado et al. proposes a system to support this individual and collaborative creative knowledge building by using concept map and ICT literacy (Maldonado, 2012). He tracked and analyzed the flow of knowledge that is created as a result of individual pre and post-concept maps at the personal computer and group concept maps construction at the multi-touch tabletop. As mentioned above, ICT literacy can offers the possibilities to extend the support to students and moreover can be an analytical tool by which teachers support students. Also, the purpose of this study is to support knowledge building by using ICT literacy. However, our study intends to different level from his study.

This paper reports practical use of Kit-Build concept map system in classroom group work for knowledge sharing and knowledge propagation among them in the learning. The remainder of this paper is organized as follows. The next section explains Kit-Build map system that is the core technology of this study. Section 3 presents the design of classes the authors conducted. These classes are conducted in a junior high school as a part of usual classes by one of the co-author. Section 4 shows the result of the class and analysis of the data. Last section concludes this paper.

2. Kit-Build Concept Map

Concept maps (Novak, 2006) are graphical tools for organizing and representing knowledge or understanding. A concept map includes concepts and relationships between concepts indicated by a connecting line linking two concepts. Two concepts linked with a relation represent a proposition. Concept map is effective for facilitating learning and for enabling learners to create visual representations of their comprehensive structure. This has enormous significance in enabling to evaluate and share learners' knowledge.

Kit-Build concept map (KB map) is a framework to build and diagnose concept maps (Yamasaki, 2010). In this method, learners build concept maps (learner map) by assembling provided parts. The parts are generated by decomposing an ideal concept map (goal map) that is prepared by a teacher as the goal of his/her teaching. The characteristic of KB maps is that it is possible to compare and overlap them because both of the maps, learner maps and goal maps are composed of the same components. Comparing them, system can calculate the concordance rate of the map as the score of learner maps automatically. KB map provides the teacher with information about learners' comprehensions and differences of their thoughts on the map that overlaps all the learner maps (group map). Also, because of providing the same parts among learner and goal maps, it is easy for students to compare their maps in discussing and negotiating understanding with maps and KB map clarify the differences between a learner's and others' understanding in creating the map collaboratively.

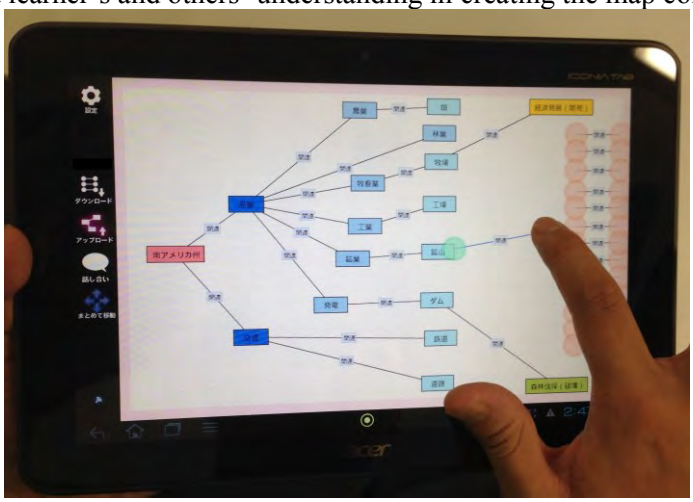

Figure 1. KB map editor.

There is a system to realize interaction based on Kit-Build method. This system is called KB map System. This system is a web application with two client systems: KB map Editor and KB map Analyzer. KB map Editor provides an environment to make a learner map. This system can be used with tablet pc (Sugihara, 2012). Figure 1 show the picture of the KB map editor. This permits students to carry their maps and to show their maps to the other students for discussing. KB map Analyzer has function to overlap learner maps and teachers understand his/her students' comprehension with this system.

3. Outline of Practice in a Junior High School Japanese Social Studies Class

3.1 the Purpose and the Design Principle of the Class

This study designed and conducted the lessons in which students use KB map. This is collaboration with the junior high school teacher that is one of the authors of this paper. He has a desire to make students enhance their understandings with both of collaboration and teaching.

In the lessons what students do is the following two things: to organize their own knowledge on KB map inductively from materials and what they have learned in the previous lessons and to compare and correct their knowledge represented on KB map through discussion. After that, the teacher explains the correct answers compared with students' KB maps. Through this process, this lesson expects that students having incorrect knowledge learn correct one from the others and that the teacher identifies students' misunderstandings still remained after discussion and teach them carefully.

3.2 Design of the Class

In this study, the procedure of the class was the following: Firstly the teacher does a review of the topics in the previous classes. The teacher shows some pictures related topics and explain it. Secondary, students make KB map (pre-map) individually. In this phase they organize their knowledge inductively from materials and what they have learned in the previous lessons. Thirdly, they go into a small group and work together. They discuss the difference among their maps and make a KB map of the group (collaborative-map) collaboratively. Fourthly, they make modify their own KB map (post-map) individually again if necessary. Lastly, the teacher gives feedback about the topic with the collaborative-maps students have made. In this procedure, pre-maps underlie collaborative-maps, and post-maps reflect collaborative-maps. The procedure of the class is shown in Figure 2.

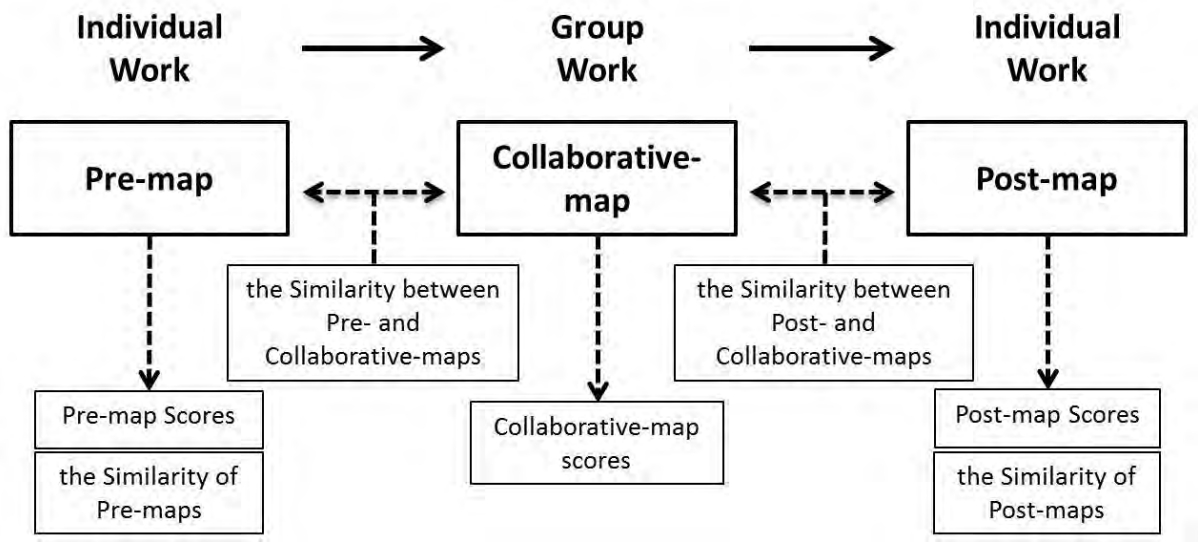

Figure 2. The Flow of This Class and the Data from the Maps.

3.3 Hypothesis

In this research, three hypotheses were formed. These are the followings:

Hypothesis 1: After group work, students have much more common understanding about the topic than before. (in a group the similarity of post-maps is higher than the one of pre-maps)
Hypothesis 2: After group work, students have much more correct understanding than before. (post-map scores are higher than pre-map scores)
Hypothesis 3: The teacher can realize the understanding of students based on group map that is made by KB map system.

3.4 Participants and Procedure of the Practice

Three lessons were conducted for three first grade classes in a junior high school. The participants are 76 Japanese students who are 12 or 13 old in total from three classes. The number of students in the class A is 26, in the class B is 25 and in the class C is also 25. In the classes, the teacher regularly uses concept maps for teaching social studies and thus, the students were used to make concept maps in learning it. In addition to that, they also have ever used KB map system in studying social studies lesson. Therefore, it is not so difficult for them to make concept maps and to use KB map system.

The subject domain of the class conducted in this study was the unit of South America in geography. The theme was the dilemma of economic development and deforestation. The students had mainly studied economic development in South America and had had knowledge about deforestation within the bounds of common sense.

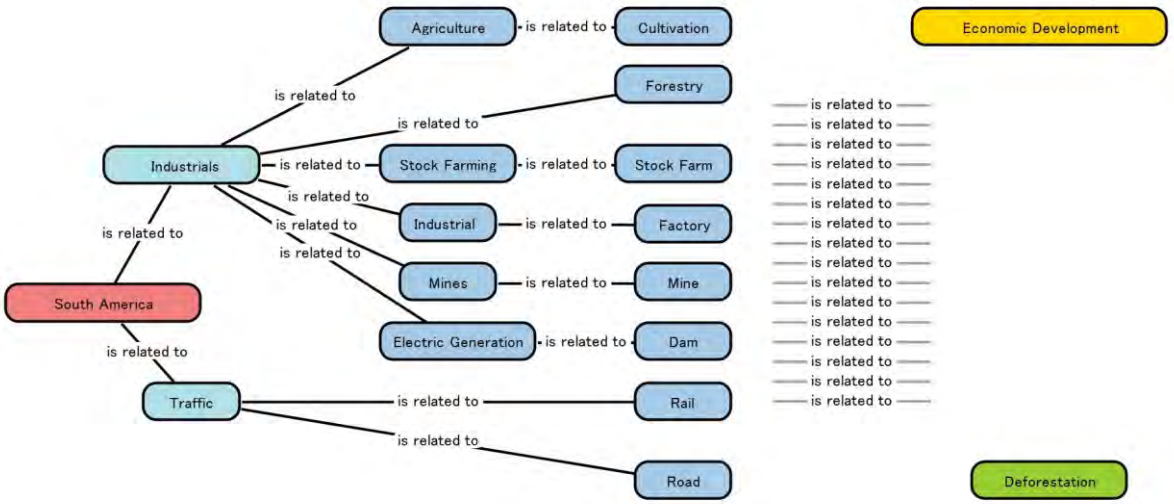

Figure 3. Kit of This Class.

In this practice, firstly the teacher makes a concept map about industrials and traffics in South America on the blackboard with the students. This map making is a task to recall what they studied in the previous classes. They made the parts of the map in several lessons. Secondly the teacher provided tablet computers with students. The kit of this class is shown in Figure 3. With a tablet, each student made a KB map including the map on the blackboard. The part of the map that is on the blackboard is already constructed on the KB map and the students are required to link the rest of it with the separated concepts and links. The separated concepts are "economic development" and "deforestation." The students are required to consider which concepts connect to economic development and/or deforestation. The kit includes enough unfixed links to connect all the concepts about industrials and traffics with both of them. In the goal map, all the separated concepts connected to both of economic development and deforestation. However, the teacher did not clearly tell the students that they did not have to use all the links. Therefore, the students must have considered whether each concept was connected with economic development and/or deforestation or not. In the previous class, the students

had learned economic developments and industrial, however, they had not learned deforestations and traffics. The teacher gave the students some documents about deforestations, and students could refer it when they made KB map. Thus, this assignment consisted of both recall and generation. Making the connection to economic development is a recall task because the teacher explained in the previous lessons. On the other hand making the connection to deforestation is a generation task because they need to consider with their pre-existing knowledge and the provided pictures. As the first step of the map making, the students make a map individually as a personal opinion. This map is called "pre-map," here. After that, they went into a small group of four or five students and discussed the difference among their maps and made a map collaboratively as an agreement. This map is called "collaborative-map," here. Next, they could modify their map individually if they need after group work. This map is called "post-map." Finally, the teacher explained the correct answer in comparison with the collaborative-maps. Here, the teacher used the group map that was made by overlapping every collaborative-map.

4. The Result and Consideration

4.1 Testing the Hypotheses

Hypothesis 1: After group work, students have much more common understanding about the topic than before (in a group the similarity of post-maps is higher than one of pre-maps)

Figure 4 and table 1 show the comparison among the average concordance rates between the pre- or post-maps in each group. It is calculated by the following equation:

$$\frac{\text{(the number of the pairs of students who connected the same link to the others)}}{\text{(the number of the propositions in goal map)} \times \text{(the number of group members)}}$$

The average concordance rate among post-maps is higher than the one among pre-maps. There is a significant difference between them in every class (in the class A: two-sample t-test, $t(5) = 4.8906$, $p<0.01$, in the class B:two-sample t-test, $t(5) = 4.0865$, $p<0.01$ and in the class C:two-sample t-test, $t(5) = 6.3571$, $p<0.01$). This indicates that students shared their understanding and built a consensus in each group in some way.

Furthermore, Figure 5 and table 1 show the comparison among the average concordance rates between pre- or post-maps and the collaborative-map in each group. This is calculated by the following equation:

$$\frac{\text{(the number of the propositions that are common between the individual and collaborative map)}}{\text{(the number of the propositions in the goal map)}}$$

The concordance rate between post- and collaborative-maps is higher than the one between pre- and collaborative-maps. There is a significant difference between them in every class (in the class A: Wilcoxon signed-rank test, $n=26$, $V=228$, $p<0.01$, in the class B: Wilcoxon signed-rank test, $n=24$, $V=153$, $p<0.01$, in the class C: Wilcoxon signed-rank test, $n=25$, $V=253$, $p<0.01$). This indicates many students changed their individual-maps following their collaborative-maps after discussion.

Hypothesis 2: After group work, students have much more correct understanding than before (post-map scores are higher than pre-map score).

Figure 5 and table 2 show the comparison between the average scores of the pre-maps and the post-maps. A score of the learner map indicates degree of similarity between the learner map and the goal map. It takes the value of 0 to 1. If the score is 1, it means the learner map is completely same as the goal map. The score is calculated by the following equation:

$$\frac{\text{(the number of the correct propositions in a learner map)}}{\text{(the number of the propositions in the goal map)}}$$

The average scores of the post-maps are higher than ones of the pre-maps in every class. There is a significant difference (in the class A: Wilcoxon signed-rank test, n=26, V=210, p<0.01, in the class B: Wilcoxon signed-rank test, n=24, V=148.5, p<0.01, in the class C: Wilcoxon signed-rank test, n=25, V=253, p<0.01) between them. This indicates that the understanding of students was improved through making the KB map in a group.

Moreover, this study compares the score of the pre-map to the score of the collaborative-map using the Wilcoxon rank sum test. A significant difference was found between the score of the pre-map and the score of the post map in every class (in the class A: n=26, U=31.5, p<0.05, in the class B: n=24, U=34, p<0.01, in the class C: n=25, U=34.5, p<0.01). The scores of the collaborative-maps are higher than the scores of the pre-maps. This finding suggests that the knowledge created collaboratively is more correct than the average knowledge created individually.

Consequently, because individual learner maps came closer to collaborative-maps, the degree of the similarity among group members' maps increased, and because the score of the collaborative-map was higher than the score of the pre-map, the students' knowledge improved.

Consequently, the summary of the results is the followings:

(1) the concordance rate of individual-maps in groups increased through group work, and
(2) the concordance rate between individual-maps and collaborative-map also increased through group work, and
(3) the score of individual-map is improved.

These can be considered as the followings:

(1') the students share their understanding in their group, and
(2') they made a collaborative-map as their shared understanding, and
(3') their shared understanding improves their individual-understanding.

The authors carried out a questionnaire survey to clarify how students had made the collaborative-maps and what is the reason if students had changed their maps after group work. This questionnaire includes two questions about decision making in group work and improvement of individual-map after it: "How did you make your collaborative-map?" and "How did you change your individual-map?" Students could choose from three options: "(1) by majority vote", "(2) agreement on the others' opinion" and "(3) by just following others' opinion". The 60-70 percentages of the students chose the second option on both questions. This suggests that students place importance on the agreement with the opinion by discussing when they change their opinion and make their collaborative knowledge. In addition to that, the relation between pre-maps and collaborative-maps shows data supporting the suggestion. Table 3 indicates the relation between pre-maps and collaborative-maps. In each group, the proposition in the pre-maps is categorized according to the number of the students that they have the same propositions in their pre-maps. Moreover, the propositions are categorized by the correctness of the propositions in their pre- and collaborative-maps. Note that students did not always choose the proposition by majority vote. Of course, they chose by majority vote, however, there are some cases that they chose from minority.

Hypothesis 3: The teacher can realize the understanding of students based on group map that is made by KB map system.

In this class, the teacher made a group map from the collaborative-maps, and compared the group map with the goal map to show how many groups did not make the correct links. Figure 7 is the group map composed of the lacking links in the collaborative-maps this study obtained in the class-A. According to the group map, the teacher could get the information about the propositions that the groups had a lack of understanding toward and were divided on the opinion of. The teacher supposed that the students had lack of understanding toward the propositions about the new concepts, railways and roadways. However, according to the group map, there was the lack of understanding toward the various propositions that the teacher did not suppose. The greatest numbers of the propositions that students had the lack of understanding about were, in class A "Forestry relate to economic developments." and "Factory relate to deforestations.", in class B "Farm relate to economic developments." and "Farm relate to deforestations.", in class C "Forestry relate to economic developments." and "colliery relate to deforestations.". In this class, teacher could explain mainly about these propositions. After the lessons the teacher said that this is the first time to get information about understanding of students on time in classroom. Although he had tried to investigate individual thought of students during group work, it needed the help of other many teachers and it is difficult to organize

the result during the lesson. This time he satisfied the information and give instruction based on it during the lesson.

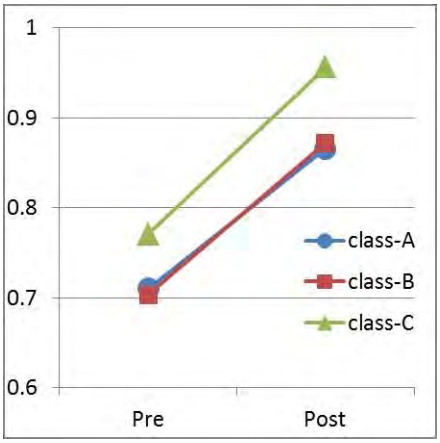

Figure 4. The Average Concordance Rate among Individual Maps in the Groups.

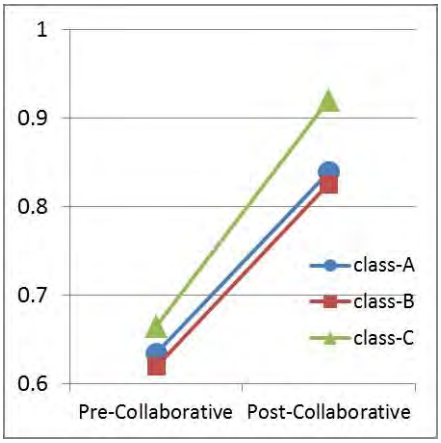

Figure 5. The Average Concordance Rate between the Individual and Collaborative Map.

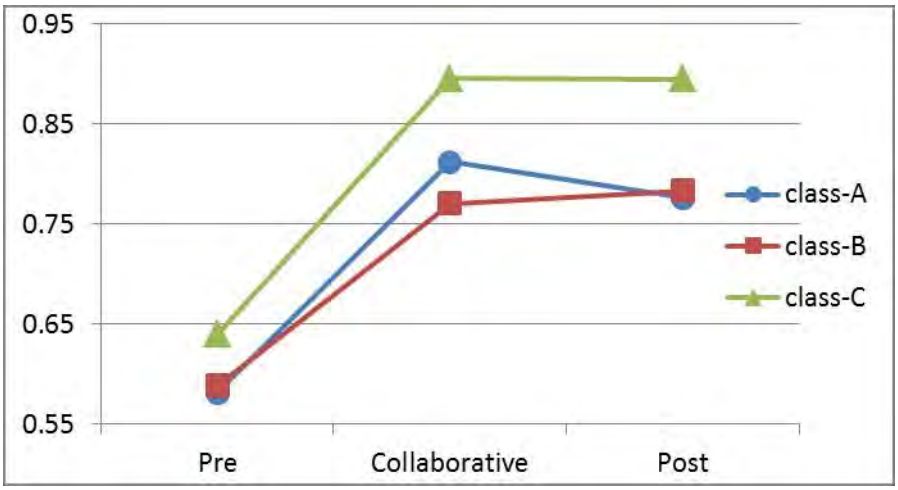

Figure 6. The Average Map Scores in three classes.

Table 1: Concordance Rates.

	Pre-maps in the group	Post-maps in the group	Pre-Collaborative	Post-Collaborative
Class-A	0.7104(*SD*=0.0399)	0.8661(*SD*=0.0462)	0.6346(*SD*=0.2170)	0.8389(*SD*=0.1563)
Class-B	0.7031(*SD*=0.0733)	0.8724(*SD*=0.0858)	0.6198(*SD*=0.1861)	0.8255(*SD*=0.1403)
Class-C	0.7708(*SD*=0.0696)	0.9563(*SD*=0.0296)	0.6650(*SD*=0.2064)	0.9200(*SD*=0.0875)

Table 2: Map Scores.

	Pre-map	Collaborative-map	Post-map
Class-A	0.5817(*SD*=0.2206)	0.8125(*SD*=0.1936)	0.7764(*SD*=0.1922)
Class-B	0.5885(*SD*=0.2395)	0.7708(*SD*=0.1407)	0.7839(*SD*=0.1758)
Class-C	0.6400(*SD*=0.2226)	0.8958(*SD*=0.1164)	0.8950(*SD*=0.0967)

Table 3: the Relation between the Pre-Maps and Collaborative-Maps.

The type of result	Unanimous accord				Majority				Even	
Which is common in pre-maps	Correct agreement		Incorrect agreement		Major correct opinion		Major Incorrect opinion		Even	
Correct or Incorrect in collaborative-maps	C	I	C	I	C	I	C	I	C	I
The number of Propositions	51	2	3	7	82	6	35	23	67	12

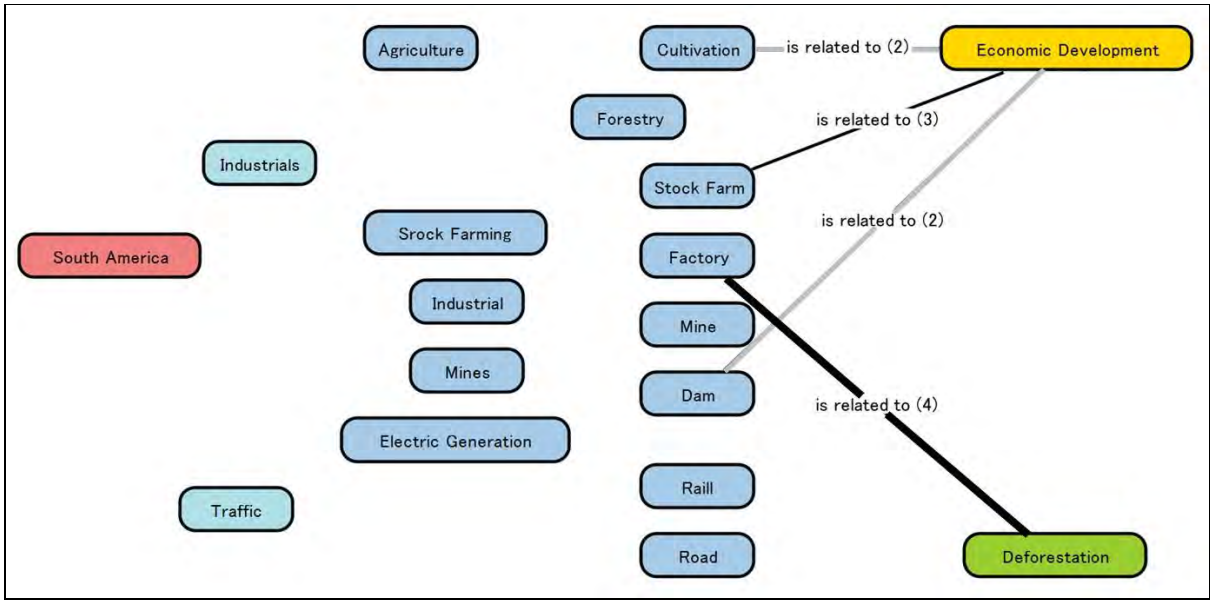

Figure7. Group Map in the Class-A.

4.2 Analysis of the Knowledge Propagation in Collaborative Learning

As mentioned above, the students' knowledge improved on the whole. However, this result is just average. Now let's take a look at the several students. The students did not improve all of their misunderstanding. Although, some students corrected their misunderstanding of some items through group work, other students went wrong in understanding of some items after group work even though they had had correct understanding. About these phenomena, this study examined the knowledge propagation in more detail.

Table 4 shows the patterns of change of understanding and the distribution of them. There are eight patterns of change among pre-, collaborative- and post-maps by the correctness of the propositions in each map. The distribution is derived from about tallied the 1200 propositions in the pre-, collaborative- and post-maps.

The most common pattern is Pattern-A: students had had correct understanding of a proposition from the beginning and then had kept it at the end. This pattern accounts for over half of all propositions. Because the average score for the pre-map was about six out of ten and it improved in post map, this may be the reason why their map score was kept.

The second most common pattern is Pattern-E: students had had incorrect understanding of a proposition at the beginning and then they changed it to correct one following the agreement in their group. This pattern accounts for over two out of ten propositions and accounts for about half of the propositions that the students got the wrong answer about in their pre-maps. This may provide significant share of the reason why their score for pre-map improved.

The third most common pattern is Pattern-H: students had had incorrect understanding of a proposition at the beginning and then they had kept it by the end. The agreement in their group is also incorrect, therefore, they did not have chance to change their understanding. This pattern accounts for over one out of ten propositions. Most of this case happened when no one had had the correct answer in the group. This suggests that it was hard for students to improve their understanding without the member who had had the correct understanding. Especially, the KB map in this study requires students to make an either-or decision. Therefore, this does not produce the diversities of opinion. The students

often reached the agreement on the wrong answer from the beginning. It seems that the students did not discuss the propositions in this situation. A similar result was found in another study with the KB map.

These data supports the result of hypotheses testing in the last section. Although the above patterns are majority, there are some other patterns. In some patterns the students changed their answer from correct one to incorrect one in the post-map.

In Pattern-C and Pattern-F the students did not follow the decision in their collaborative-map and kept their own understanding that is different from the group's decision. In Pattern-D the students changed their correct understanding to incorrect one following the incorrect group decision. The number of Pattern-C is twice the number of Pattern-D. This may suggest that students prefer to keep their correct answer than to get groups' wrong answer.

Pattern-G and pattern-B mean that although a proposition in the pre-map was same to the propositions in the collaborative-map they change the proposition in the post map. They changed their thought after group work. However, there is no data to identify the reason in this study. In order to identify it, it is necessary to gather data about what they talked about in the group work other than data about KB map.

Regarding the propositions that changed from the pre-map to the post map, such as pattern-B, -D, -E and –G, nine out of ten propositions changed from incorrect to correct. Moreover, in this case, nine out of ten propositions changed to the propositions that were made collaboratively.

Table 4: the Patterns of Change of Understanding.

Pattern	Pre	Collaborative	Post	Rate (%)
A	Correct	Correct	Correct	53
B	Correct	Correct	Incorrect	1
C	Correct	Incorrect	Correct	4
D	Correct	Incorrect	Incorrect	2
E	Incorrect	Correct	Correct	23
F	Incorrect	Correct	Incorrect	6
G	Incorrect	Incorrect	Correct	2
H	Incorrect	Incorrect	Incorrect	9

5. Conclusions and Future Work

This study proposed learning activities with KB map in a group for knowledge construction and sharing prior to development of creativity, and implemented it to investigate the knowledge propagations among students. The result supports the three hypotheses, "Students share their understandings through discussion," "Students' understandings get close to the correct one" and "Teachers can teach based on the group map." Moreover, knowledge propagation in their learning is analyzed from the pre-maps to post- ones by way of collaborative- ones. Consequently, there were every possible patterns and the majority of the propositions changed to correct, however, some propositions changed to wrong.

From these results, students could acquire and correct their knowledge through the proposed group work. In knowledge propagation analyzed in Section 4.2 most of students keep their correct knowledge and correct it through discussion. This tells that the proposed method did not give negative effect on students in this case. KB map gives students with common parts to build a concept map. This might be effective in discussion. If the students built concept maps freely it would be difficult for them to organize their thought at a short time. This is highly controversial issue and must be investigated in the future.

The aim of the classes proposed in this study is to build common knowledge among students before forming the creative opinions in the next class. Therefore, what is important is to let learners be with a full understanding of basic knowledge required for forming creative opinions. To that end, learners must keep the correct knowledge and change the incorrect knowledge to correct. In the proposed classes, the students improved their understanding through group work with KB map after learning the subject. Also, with KB map, the teacher could teach about the propositions that the students did not understand well and conduct personal coaching based on the data from KB map the students made.

These classes were implemented in the regular classes and there is no data to improve the improvement of students' understanding. It is necessary to measure their understandings with other tests and to compare the effectiveness with learning methods. However, at least, the teacher conduct this classes said that he feels the reciprocal teaching by students have worked well and KB map is useful not only learners but also teachers to organize what to learn and recognize students' understanding.

Of course, the aim of this study is not general in the research area of collaborative learning. Most of studies focus on discovery learning in which students build their own knowledge other than knowledge given by teachers. However, Scardamalia distinguishes it into "guided discovery" and "knowledge building" (Scardamalia, 2007). The proposed lesson in this study can be considered as a kind of the former one. In this type of discovery learning learners try to discover a solution of a problem that have correct answers. Although, this does not require creativity in the true sense, they are required creative thinking. The authors think that the advantage of this style of discovery learning is the existence of correct answer and teachers can make clear assessment on the answers of learners. This is expected to use for training of creative thinking. In fact, KB map building in the lessons required the students to think about things other than they had learned. They needed to make a conjecture from the materials given in the lessons. Although this is closed in the KB map and the materials, thinking process is similar to inductive thinking in true discovery learning.

In addition to that, further research on this collaborative learning with KB map would clarify the knowledge propagation. A further direction of this study will be to support the classes for acquiring advanced knowledge by collaborative learning with KB map.

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