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Practical Use of Kit-Build Concept Map System for Formative Assessment of Learners' Comprehension in a Lecture

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Abstract. This paper described a practical use of kit-build concept map (KBCM) in science learning class in an elementary school in order to evaluate learners' understanding ongoing the teaching. The responsible teacher of the class reported that the information provided from KBCM is useful to decide complementary teaching ongoing class and improve his lesson plan of the next class. We have confirmed that the map scores in KBCM have significant correlation with the scores of standard test of science learning. This case study suggests that KBCM is a promising tool to estimate learners' understanding in classroom.
Keywords: kit-build, concept map, formative assessment

1. Introduction

It is usually difficult for a teacher to estimate learner's comprehension for his/her lecture, although it is indispensable to complement and improve his/her teaching (Sadler, 1989). Concept map (Novak & Gowin, 1984) is promising way to assess learners' comprehension but it is usually difficult for learners to build and hard for teachers to compare or evaluate because the components of concept maps are often different. Kit-build concept map is a new framework to build and diagnose concept maps (Funaoi, 2011 &Yamasaki, 2010 & Sugihara, 2012).

In this paper, we report two practical uses of kit-build concept map system (KBCM) in science lessons in an elementary school as a realization of instantaneous assessment of learners' comprehension for the contents of teaching. This assessment is a kind of formative assessment (Sadler, 1989) that is an important topic of technology-enhanced learning (Beatty, 2009 & Lee, 2012). In KBCM, a learner makes a concept map by assembling provided parts (we call this method "kit-build"). The parts, then, are generated by decomposing an ideal concept map that is prepared by a teacher as the goal of his/her teaching. Because both the maps made by learners (learner map) and the ideal map made by the teacher (goal map) are composed of the same components, it is possible to compare or overlap them. KBCM provides the teacher with information about learners' comprehension as a map made by overlapping all learner maps (group map), differences between the group map and the goal map. The teacher is also able to check each learner map and compare it with the group map, goal map or another learner map.

Through the practical uses of KBCM, the responsible teacher of the classes judged that the information provided from KBCM was useful to grasp learners' comprehension and the teacher was able to improve his ongoing and the next teaching based on the information. Then, we found that there was positive correlation between scores of leaner maps calculated by comparing students' maps with the goal map and their scores on a standard assessment test as for learners in the first class. These results suggest that KBCM is a promising approach to realize instantaneous assessment of learners' comprehension for a lecture. In this paper, two practices and results are reported. The content of the first lecture was "The sun's orbit seen from the northern hemisphere", and that of the second one was "The sun's orbit seen from the southern hemisphere".

2. Procedure of the First Practice

Teaching with KBCM was carried out for two classes in the third grade in an elementary school. There were 38 learners in each class. The procedure of the teaching was as follows.

1. The teacher selected a topic of the lesson and made a teaching plan for the topic. In this practice, the topic was “Seen from the northern hemisphere, the sun rises from the eastern sky, passes through the southern sky, and sets in the western sky”. The teacher planned to use two class times (one class time is 45 minutes) for this topic.
2. The teacher creates a concept map that expresses the goal of comprehension of the lesson. The goal map is shown in Figure 1.
3. The teacher taught the topic at the first class.
4. In the middle of the class, the teacher required the learners to make a map with KBCM in order to confirm their understanding. Leaner interface of KBCM is implemented on media tablets. Then, each learner made his/her map with his/her media tablet. It took about five minutes. When learners made their maps, they walked around freely and talked each other. This is a way to use KBCM in collaborative learning situation (Hirashima, 2011). The scene is shown in Figure 2. This is an important benefit to implement KBCM with media tablet (Sugihara, 2012). After this collaboration, the learners had improved their understanding.
5. Learner maps were sent to KBCM server through wireless LAN and diagnosed by overlapping and comparing. By comparing the group map with the goal map, it is possible to generate a kind of group map that is composed of lacking links in the learner maps. Figure 3 is the group map composed of the lacking links we obtained in the first class. This map can be generated by comparing the group map and goal map, and then, displaying only lacking links. The bracketed numbers indicate the number of learner maps that don't include the corresponding link. This map informed the teacher that the learners tended to overlook “passes through” link between “Sun” and “Southern sky” (that is, fifteen learners in the class could not linked correctly) and “doesn’t pass through” link between “Sun” and “Northern sky” (that is, thirteen learners could not linked correctly).
6. The teacher examined the information provided from KBCM and found weak points of learners’ comprehension of the first class. As mentioned in above step, the teacher found that “passes through” link between “Sun” and “Southern sky” and “doesn’t pass through” link between “Sun” and “Northern sky” were weak point of the learners. Therefore, the teacher made supplemental explanation based on the information.
7. The teacher required the learners to make a map and upload it again. Then, the teacher checked the maps in the same way with the step 5.
8. The teacher made a supplemental explanation with KBCM again in the same way as he had done in the step 6.
9. At the end of the class, the teacher required the learners to make a map to confirm their final comprehension.
10. The teacher modified the lesson plan of the second class immediately based on the results of the first class in order to emphasis the links that the learners overlooked in the first class. Then, by using the modified lesson plan, the teacher conducted the class.

The teacher planned to teach “the sun’s orbit seen from northern hemisphere” in the first class time, and “the sun’s orbit seen from southern hemisphere” as an advanced topic in the second one. This was because the teacher thought that the learners would understand the contents about “the sun’s orbit seen from northern hemisphere” immediately. However, in fact, the teacher found that they didn’t understand as well as he estimated by looking the lacking links. Then the teacher modified the lecture plan, and taught more precisely about “the sun’s orbit seen from northern hemisphere”.

In this way, the teacher could perform the flexible lecture checking the students’ understanding with the ongoing assessment provided from KBCM. The topic of the second practice was “the sun’s orbit seen from southern hemisphere”, which had not been taught in the first practice.

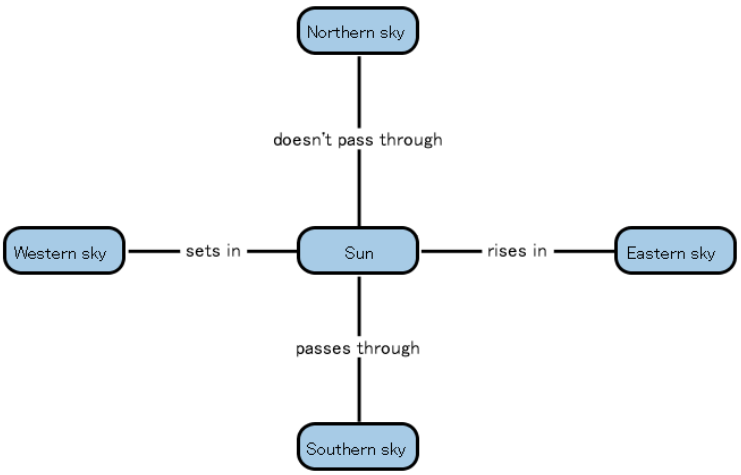

Figure 35. Goal Map of the First Practice

Figure 36. Learners Building Concept Maps in Classroom

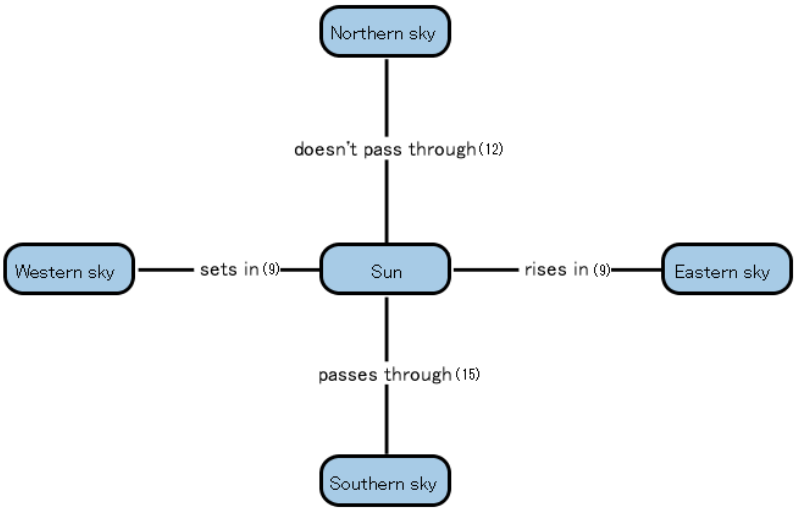

Figure 37. Group Map Composed with Lacking Links

3. Analysis of the Results of the First Practice

3.1 Comparison Map Scores with Standard Test Scores

The score of the leaner map is calculated by (number of correctly connected links in a learner map) / (number of links in the goal map). It represents the degree of coincidence of learner's map and goal map, and takes the value of 0 to 1. We have compared the learner's map scores with learner's standard assessment test scores of science that were carried out to evaluate general ability of science. The test was carried out before the lesson, so it doesn't cover the topic in this lesson. Here, we cite the test scores to compare learners' general ability of science with their map quality.

In the first class, the average final map score was 0.882 (*SD*=0.0.285). As for these learners, the correlation coefficient between the scores of the final learner maps and the scores of the standard assessment test of science was 0.337. The result was statistically significant (*N*=38, *p*=0.039). This means that higher ability learners in science made better concept maps. In addition, the correlation coefficient between the scores of the final learner maps and the scores of the mini-test (about the same topic as the map) was 0.395. The result was statistically significant (*N*=38, *p*=0.014). These facts suggest that the map quality would reflect learner's comprehension for the topic.

In contract, as for the second class learners, their average final map score was 0.967 (*SD*=0.117) and the correlation coefficient between the scores of the final learner maps and the scores of the standard assessment test of science was -0.170 (p=0.307), and the correlation coefficient between the scores of the final learner maps and the scores of the mini-test was 0.284 (p=0.081). In this class, even learners with low ability in science could understand the lesson enough thanks to the effect of the improvement based on the information provided from KBCM. That caused a celling effect, and it made the correlation coefficient low. The scatter grams of Figure 4 and Figure 5 show the relationship between map scores and mini-test scores of each class.

The celling effect is shown on the scatter gram of the second class. As for the second class, the average of map scores is 0.967 and the standard deviation is 0.117. The sum of these is 1.084. This is higher than the maximum value map score can take. In this way, the ceiling effect of the second class is statistically confirmed.

Table 20. Correlative Coefficients Between Final Map Scores and Standard Test Scores, and mini-test scores

	1st class	2nd class
General science test	0.337 (p=0.039)	-0.170 (p=0.307)
Mini-test	0.395 (p=0.014)	0.284 (p=0.081)

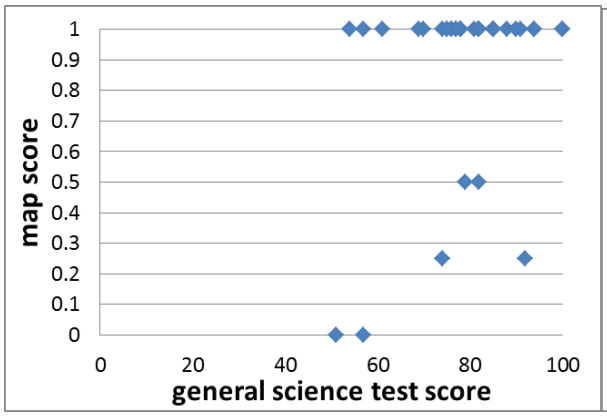

Figure 4. Mini-test and Final Map Scores in the 1st Class.

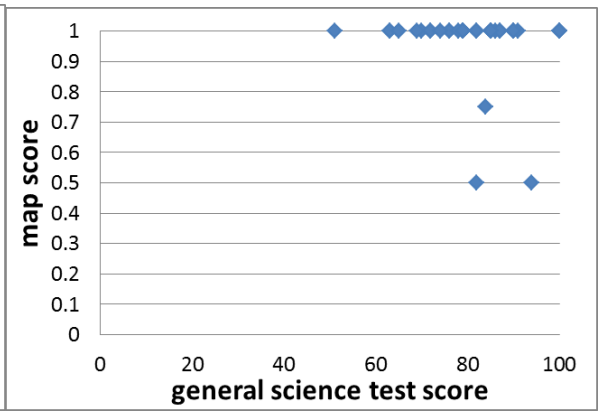

Figure 5. Mini-test and Final Map Scores in the 2nd Class.

3.2 Internal-Class Improvement

Figure 6 shows the user interface of the system that the teacher in a class used to check learners' comprehension. Right side is the area to show several kinds of group maps and left side is the area to modify the group map. It is possible to show or hide lacking links and excess links of all learners in the group map. Excess link is a link that is contained in the learner's map but isn't contained in the goal map. It represents the learner's misunderstanding. Contrary, lacking link is a link that isn't

contained in the learner's map but is contained in the goal map. It represents where the learner doesn't understand. By moving the sliders on the left side of the interface, it is possible to view only lacking links or excess links of large numbers.

The teacher noted that the system brought effective information that the teacher didn't expected, and he reported that it was impossible to gasp such understanding situation of learners without the system. Figure 7 and 8 show the number of lacking links in each class. The teacher checked lacking links in first maps, and conduct complementary explanation for the learners to promote the understanding of the links. In this practice, the teacher modified the visualized links of the group map and showed it the learners directly when he gave supplementary teaching in order to focus their attention. The learners also paid special attention to the shown map and links and accepted they were reflected their comprehension.

3.3 Cross-Class Improvement

The teacher not only conducted supplementary teaching based on the information he grasped from the group maps, but also modified the lesson plan of the second class. Because the second class was scheduled just after the first class, he didn't change the main story or materials but take care to emphasis and explain politely concerning the lacking links. Of course, there was explanation related to the links but the teacher judged that the explanation was not enough.

Table 2 shows averages of science test scores and map scores of each class. The average final map score of the second class is higher than that of the first class. The difference is marginally significant ($p=0.096$). The difference is not so significant, but it seems that this is because the averages of scores are too close to the upper limit of the score. Besides, there is no significant difference between the averages of science test scores of each class ($p=0.624$). These facts suggest that the improvement of the lesson was effective.

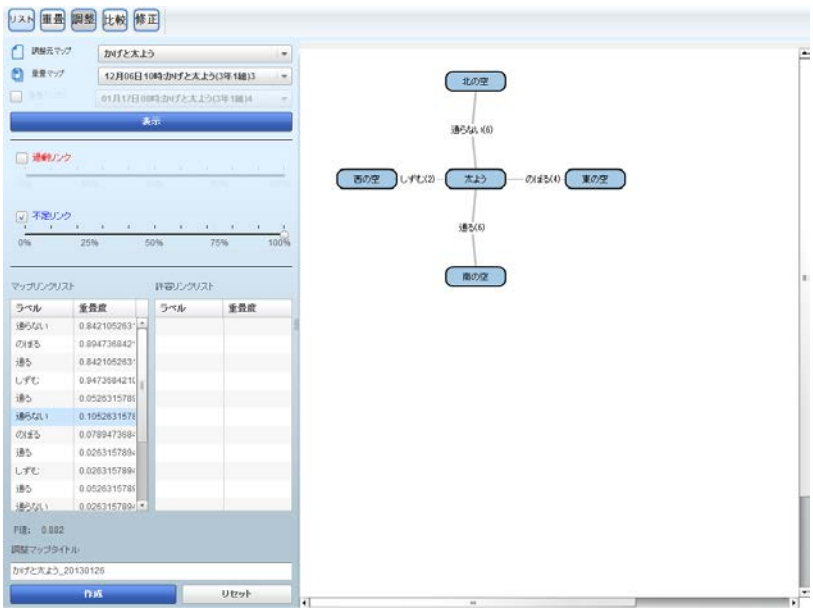

Figure 6. User Interface for Teacher to Check Learners' Understanding.

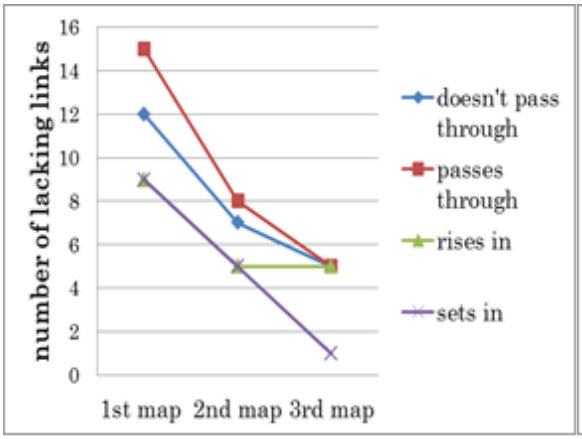

Figure 7. Lacking links in the 1st Practice, 1st Class

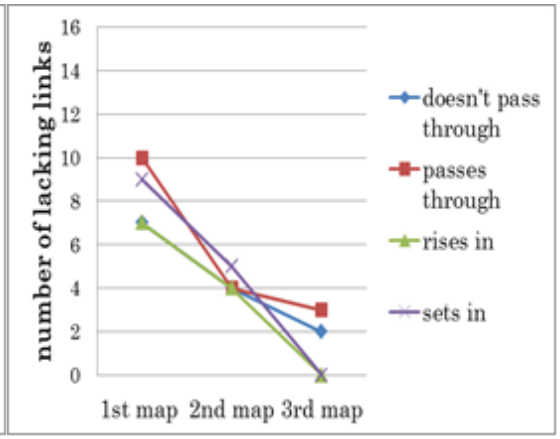

Figure 8. Lacking links in the 1st Practice, 2nd Class

Table 2. Map Scores of each class in the first practice

	1st class	2nd class
Average 1st map score （/1）	0.704	0.783
Average 2nd map score (/1)	0.809	0.888
Average 3rd map score (/1)	0.882	0.967

4. Procedure of the Second Practice

The second practice was carried out for two classes in the third grade in an elementary school. The students are the same as those in the first practice. There were 38 learners in each class. The procedure of the teaching was almost same as that in the first practice. After the teacher taught the topic, he required the learners to make a map three times. Explanations were made by the teacher between the map makings. Figure 9 shows the goal map of this practice.

In this practice, students made groups composed of four students, and talked each other using terrestrial globes and lights and small dolls (about 3 centimeters tall) to think about the sun's location seen from Australia. The students considered in which direction the sun can be seen from Australia by exposing the terrestrial globe to light from the just beside. With the fixed light and spinning the terrestrial globe, they thought in which direction in the sky the light begins to appear, passes through, and begins to disappear. The doll was put on Australia on the terrestrial globe, and learners thought in which direction in the sky the doll can see the light.

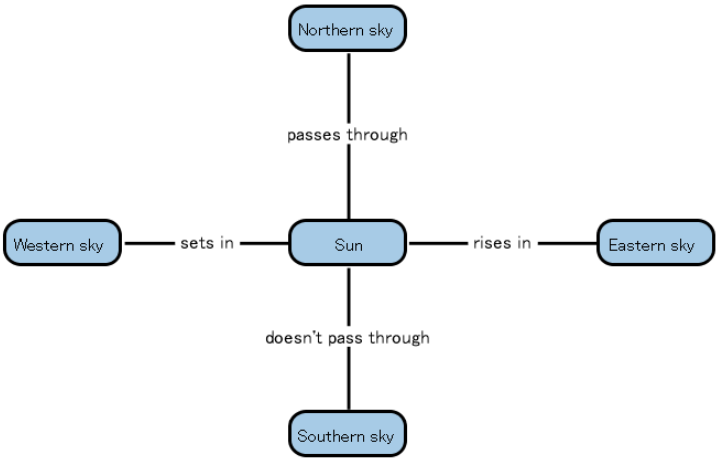

Figure 9. Goal Map of the Second Practice

5. Analysis of the Results of the Second Practice

5.1 Comparison Map Scores with Standard Test Scores

Like the first practice, we have compared the learner's map scores with learner's standard assessment test scores of science.

In the first class, the average final map score was 0.638 (*SD*=0.279). As for these learners, the correlation coefficient between the scores of the final learner maps and the scores of the standard assessment test of science was 0.056. The result was not statistically significant (*N*=38, *p*=0.740). In contract, as for the second class learners, their average final map score was 0.914 (*SD*=0.201) and the correlation coefficient between the scores of the final learner maps and the scores of the standard assessment test of science was 0.391 (*p*=0.015).

Because the topic of this practice was advanced one, the distribution of the map score was partial towards the bottom. That made the correlation coefficient low. Contrary, in the second class, more students understood the contents of the lecture than those in the first class thanks to the improved lecture. Then the correlation between map scores and science test scores became significant. The scatter grams of Figure 10 and Figure 11 show the relationship between map scores and science test scores of each class.

Table 3: Correlative Coefficients Between Final Map Scores and Standard Test Scores, and mini-test scores

	1st class	2nd class
General science test	0.337 (p=0.039)	-0.170 (p=0.307)
Mini-test	0.395 (p=0.014)	0.284 (p=0.081)

Figure 10. Mini-test and Final Map Scores in the 1st Class.

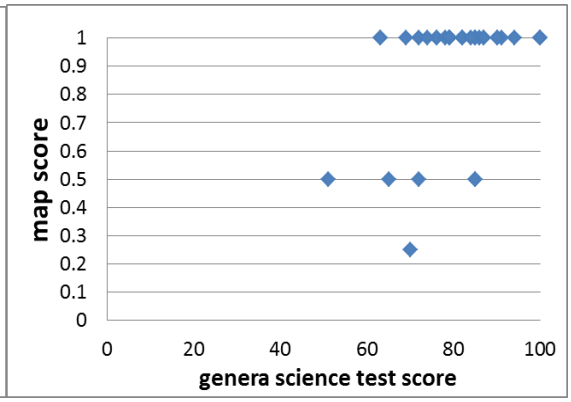

Figure 11. Mini-test and Final Map Scores in the 2nd Class.

5.2 *Internal-Class Improvement*

Figure 12 and 13 show the number of lacking links in each class.

In the first class, there were more lacking links about northern sky and southern sky in the first maps than in the second ones. The teacher confirmed that, and changed the plan of the lecture. After the students made and uploaded the second map, the teacher gathered students around a platform, and explained how the sun is seen from Australia using a terrestrial globe and a light and a doll. That was different from the teacher's plan. He planned to have students think by themselves at that time.

In this way, the teacher could change the lecture plan and make the flexible lecture taking learners' understanding into account with KBCM.

5.3 Cross-Class Improvement

In thinking with a terrestrial globe and a light, you should take the slope of the earth's axis into account, and take care of from which direction you pose the light to the terrestrial globe. Without that, it is difficult to think in which direction in the sky the sun can be seen from Australia when the sun is in just front of Australia (at noon). If the relative position of the light and the terrestrial globe is same as that of the sun and the earth in winter, it is easy to notice that the light can be seen in the northern sky from Australia at noon, while if the relative position is the summer's, it is difficult to notice that the sun can be seen in the northern sky from Australia at noon because the light which posed from the just beside is seen almost just above Australia. So in thinking in which direction of the sky the sun can be seen from Australia at noon, you can take easiness by placing the terrestrial globe and the light in the relative position in winter.

In the first class, there were many students who didn't realize that the sun passes through northern sky and doesn't pass through southern sky because the relative position was not indicated by the teacher. Contrary, in the second one, it was indicated and more students realized that. Figure 9 and Figure 10 show the numbers of lacking links in each map in each class. These show that the numbers of lacking links "passes through" and "doesn't pass through" declined as the lecture proceeded in the second class, while in the first one, the numbers of those lacking links increased. It suggests that the consideration using a terrestrial globe and a light without the appropriate indication caused students' misunderstanding.

Besides, the lacking links related to eastern sky and western sky are declined in number in both of the classes. This was because simply using a terrestrial globe and a light, these contents become more understandable regardless of the relative location of the sun and the earth. In this way, we have confirmed that the teacher could improve what he wanted to improve indeed, and how it was realized.

Table 4 shows averages of science test scores and map scores of each class. The average final map score which represents students' final understanding of the second class was higher than that of the first class. The difference is statistically significant. Besides, there is no significant difference between averages of science test scores of each class. These facts suggest that the improvement of the lesson was effective.

In the first class, the teacher judged the contents of the lesson was more difficult for the students than he expected, and then he changed the flow of the lecture in the second class. The students of the first class didn't think with terrestrial globes before the first map making, while those of the second one did it before the first map making. This is why the first maps in the first class had many lacking links related to eastern sky and western sky, while the first maps in the second class had little those lacking links.

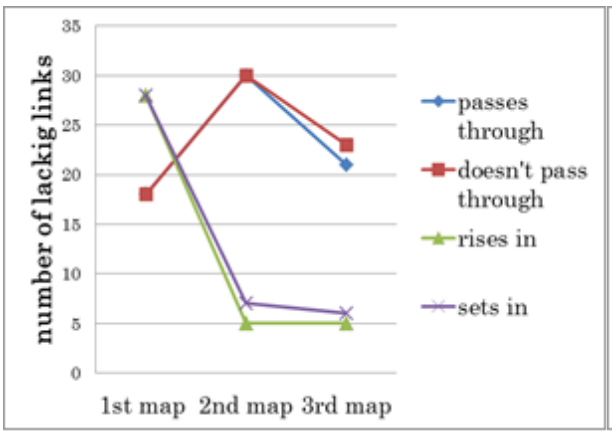

Figure 12. Lacking Links in the 2nd Practice, 1st Class

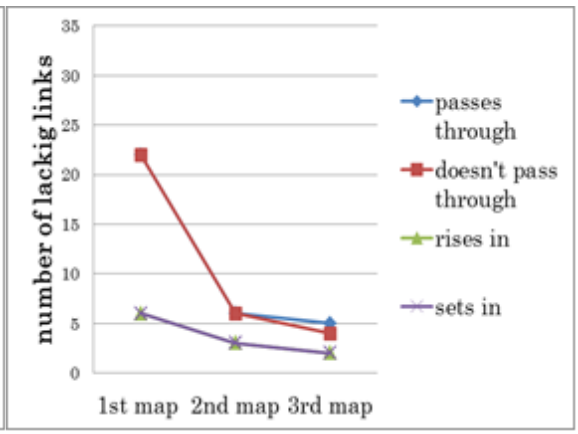

Figure 13. Lacking Links in the 2nd Practice, 2nd Class

Table 4. Map Scores of each class in the second practice

	1st class	2nd class
Average 1st map score （/1）	0.395	0.632
Average 2nd map score (/1)	0.526	0.882
Average 3rd map score (/1)	0.638	0.914

5.4 *Questionnaire*

After the lectures, we conducted a questionnaire survey on the students. The questions are shown on Figure 14, and five-point scale was used. The averages of each question in each class are also shown. We gained totally positive opinions from the students of both classes, for example, “It was fun to make maps”, and “It was easy to make maps”. This suggests that students of third grade in an elementary school have no problem in making KB maps.

Besides, as for the question “Did you talk each other when you made your maps?” the average in the second class is higher than that of first one. It seems that this was because the number of students who understood the contents increased in the second class thanks to the improved lecture, and then they could share their opinions actively.

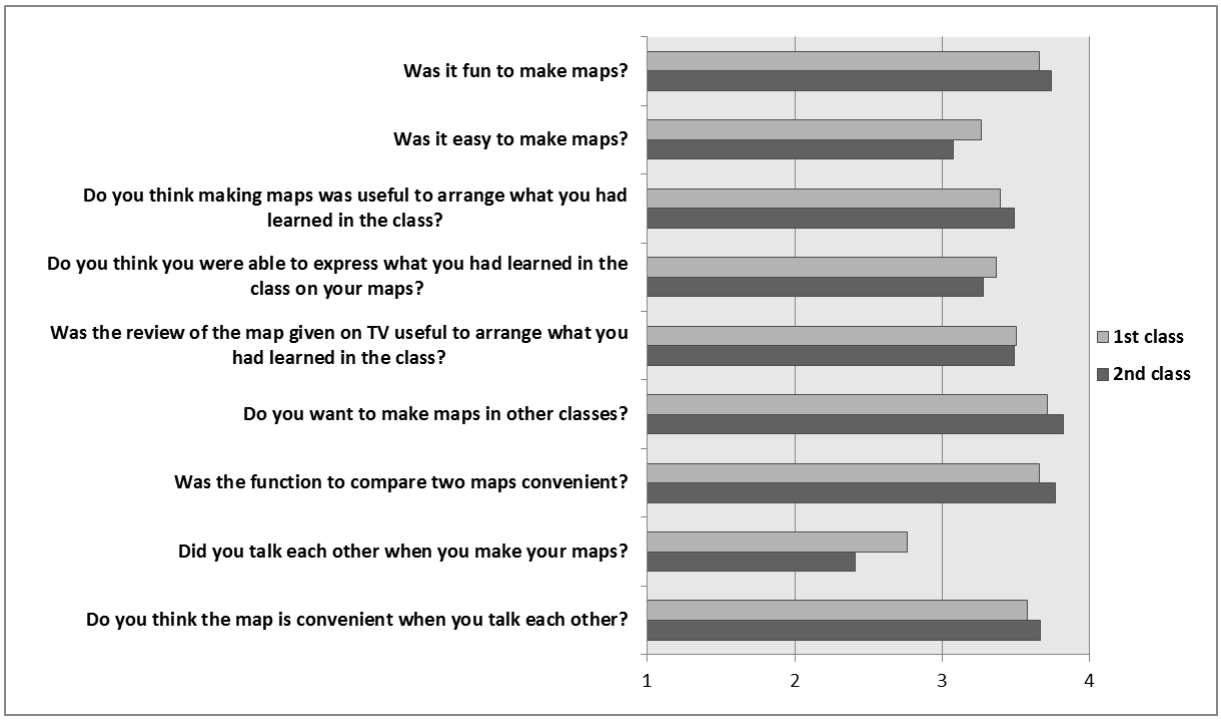

Figure 14. Result of the Questionnaire

6. Conclusion remarks

The teacher thinks that assembling a concept map with Kit-Build system and answering to a mini test has the almost same meaning as a method to check students’ understanding, and that the former is superior because of its automatic and real-time analysis. Besides, positive evaluations were gained from the students by the questionnaire. From these and the analysis of the results, we conclude that the use of Kit-Build system was useful as a method to check students’ understanding. To extend the size of practice and confirm the usefulness of KBCM are our important future work.

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