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Comparison between Kit-Building Task of Concept Map and Multiple Choice Task of Fill-in-the-blank Question Generated from the Same Series of Propositions

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Abstract: We have already proposed a framework of kit-build concept map where a learner is provided a set of parts of a concept map and is requested to build a concept map by composing the parts. In this framework, a build map by a learner is able to be diagnosed automatically. The kit-building task of a concept map is a promising exercise for strengthening and assessing learner's comprehension for a topic that a learner already has learnt. We have implemented an interactive learning environment based on the framework and practically used the environment in several schools. In this paper, in order to investigate the value of the kit-building task of a concept map, we compare it with multiple-choice task of fill-in-the-blank questions. The multiple choice task of fill-in-the-blank questions is also used to strengthen and assess learner's comprehension, and the answer can be automatically evaluated. Then, the both task can be generated from the same series of propositions, that is, from the same contents. We have compared the two tasks through 3 lessons of science learning of 5th grade students in two classes. One class used KB map (KB class) and another class used Fill-In-the-Blank questions (FIB class). Individual student in both classes used a tablet PC. The tablet PC was connected to a server though wireless LAN and a teacher could receive the results of evaluations of the maps or answers' of the questions immediately. Based on the evaluation results, the teacher conducted additional teaching. As the results, the KB task evaluated learner's comprehension more adequately than the question task, and the students in the KB class had higher performance than the students in the question class.

Keywords: Kit-Build Task of Concept Map, Multiple Choice Task of Fill-in-the-blank Questions, Strengthening of Comprehension, Assessing of Comprehension

1. Introduction

Concept map is a diagram that depicts relationships between nodes that expressing a topic (Novak et. al., 2006). This diagram is often used as a tool to structurally represent idea or knowledge in various situations. In education, the concept map is used as a tool to let a student to express their understanding for a target learning topic (Novak, 1990). There are many investigations that report the learning effects to use the concept map. However, concept maps built by students' with their own words are very difficult for teachers to evaluate them immediately. Therefore, although the concept map is useful as learning activity and is able to be useful for summative assessment, it is difficult to realize real time feedback based on evaluations of the concept maps.

In Kit-Build Concept map (KB map in short), all components, that is, nodes and links are provided to a student, and then, the student is required to build a concept map by combining them to express their understanding for a lecture(Yamasaki, et.al., 2010, Hirashima et. al., 2011, Hirashima, et. al., 2015). Therefore, the kit-building task of a concept map is a promising exercise for

strengthening and assessing learner's comprehension for a topic that a learner already has learnt. The components are generated by decomposing a teacher map that is built by a teacher who conducts the lecture as an ideal understanding for the lecture. The map build by a student is easily compared with the teacher map because all components are the same ones. Therefore, the KB map framework realizes automatic evaluation of a concept map as comparing with a teacher map. We have already implemented the KB map framework and practically used it in several elementary schools. The results have suggested that using KB map has learning effects (Sugihara, et. al., 2012).

In this paper, in order to investigate the value of the kit-building task of a concept map, we compare it with multiple-choice task of Fill-In-the-Blank (FIB) questions. The multiple choice task of fill-in-the-blank questions is also used to strengthen and assess learner's comprehension, and the answer can be automatically evaluated. Then, the both task can be generated from the same series of propositions, that is, from the same contents. Because of these two reasons, it is adequate to investigate the value of the KB map task by comparing with the FIB questions task. As a learning task, the KB map task and the FIB question task are categorized as learning by recalling or paraphrasing. In recalling or paraphrasing, usually memory is reconstructed and the reconstruction has learning effect (Teun et. al.,1983, Roediger, et. al.,2015). In this research, we try to find difference between the KB map task and the FIB question task in learning effect and assessment of comprehension.

In this research, we have implemented an authoring tool that supports to generate (1) Kit-Building Task of Concept Map, and (2) Multiple Choice Task of Fill-in-the-blank Questions from a series of propositions. In the practical use of KB map and FIB questions, 5th grade students in two classes received 3 lessons of science learning. One class used KB map (KB class) and another class used FIB questions (FIB class). Individual student in both classes used a tablet PC to build KB map and answer questions. The tablet PC was connected to a server though wireless LAN and a teacher could receive the results of evaluations of the maps or answers of the questions from the server immediately. Based on the evaluation results, the teacher was allowed to conduct additional teaching. As the results, the KB task evaluated learner's comprehension more adequately than the question task, and the students in the KB class had higher performance than the students in the question class.

In this paper, in Section 2, relationship between FIB questions and KB map are explained in more details. In Section 3, implementation of the authoring tool is explained. In Section 4, experimental uses of KB map and FIB questions are explained and comparison of learning effects of them is reported.

2. Relationship between Fill-In-the-Blank Questions and Kit-Build Concept Map

A semantic unit of concept map is a combination of two nodes representing two concepts respectively and one link representing relationship between the two concepts. The link has a link word/phrase to specify the relationship. The combination of two nodes and one relationship represents a proposition. In other words, a concept map expresses a series of propositions. Semantic network (Carbonell, 1970) and RDF expression (RDF Working Group, 2004)have adopted the same notational system and they have the same ability to represent semantics basically. In this paper, a concept map is regarded as a set of propositions composed of two concepts and one relationship

For an example, in a topic of "Movement of the Sun" in science learning in elementary school, it is possible to depict a teacher map as shown in Figure 1. This teacher map was used in a practice reported in (Yoshida et. al., 2013). This teacher map is composed of four propositions: (1) the "sun" "rises in" the "eastern sky", (2) the "sun" "passes through" the "southern sky", (3) the "sun" "sits in" the "western sky", and (4) the "sun" "doesn't pass through" the "northern sky". These four propositions are connects by "sun" and form a series of propositions. Here, a colored rectangle expresses a node and a phrase composed of one or few words in the rectangle expresses the label of the node. We call the phrase "node label". A phrase in white rectangle between two nodes expresses a label of link. We call the phrase "link label". "Western sky" and "Sun" are node labels and "Sets in" is a link label.

In this case, when a teacher inputs the four sentences and specifies three parts (one or a few words) corresponding to two nodes and one relationship in each sentence, the four sentences are

regards as four propositions. Because the propositions are connected to a series of ones, a concept map is generated. This is a procedure of authoring of a concept map from a set of sentences. When a series of propositions is generated, it is possible to generate FIB questions by specifying a blank in each proposition. For an example, when all link words are specified as blanks in the above propositions, four FIB questions are generated from the same content. This is a procedure of authoring of FIB questions from the same content with a concept map.

There are several automatic assessment methods of concept map. CmapTools is a representative implementation of automatic assessment of concept map (Novak et. al., 2006). However, CmapTools allows students use their own words as node and link words. Therefore, CmapTools has adopted synonyms matching. Therefore, as right/wrong judgement of a proposition, it is not reliable. In contract to CmapTools, KB map is able to precisely judge right/wrong to each proposition. CMT Mapping Tool realizes automatic and precise assessment in the level of propositions (Ben, 2010). However, CMT requests a teacher to build a map formal way that can be assessed by using diagnosis rules. This kind of concept map is often called formal concept map. Formal concept map is usually very difficult to adequately prepare because it requires knowledge not only the domain but also knowledge engineering. Current our target is a concept map that a usual teacher is able to prepare. Such concept map is often called informal concept map. KB map realizes automatic assessment in the level of proposition for informal concept map.

From viewpoint of these assessment characteristics, a set of FIB questions has the similar ability. Therefore, in this research, we realized activities of KB map building and answering FIB questions for the same content and compared their learning effects. Procedure of authoring KB map and FIB questions in this research shown in Figure 2. In this example, a teacher writes a summary about "movement of the sun" as a learning topic (step-1) at first. Each sentence consisting of the summary is required to form a proposition. Then, the teacher is requested to specify two concepts (as node labels) and a relationship (as a link label) in each sentence. By the specification, a proposition is made from a sentence. So, a set of propositions are generated from a summary (step-2). From the set of propositions, a concept map for the learning topic is generated (step A-1). This map is a teacher map. If the propositions are not connected to one, the teacher is required to modify the sentences or specification of nodes or link. By decomposing the teacher map, a set of components that are provided to students are generated (step A-2). In order to make FIB questions, the teacher is required to specify a place to make the blank in each sentence. The place should be corresponds to a node label or a link label (step B). Consequently, both KB map and FIB questions are made from the same proposition set. And then, both are possible to realize automatic assessment in proposition level.

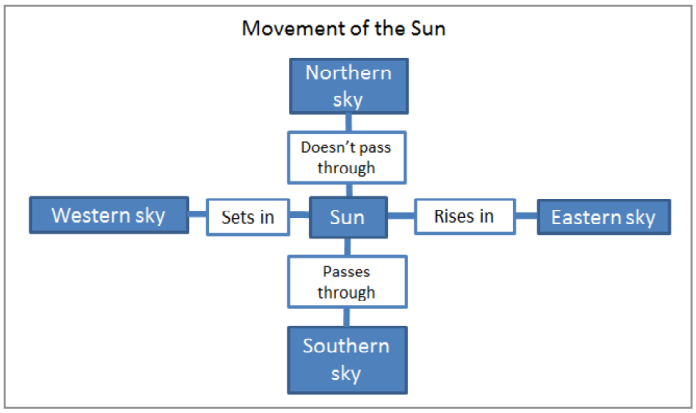

Figure 1 One example of a teacher of the map about "Movement of the Sun"

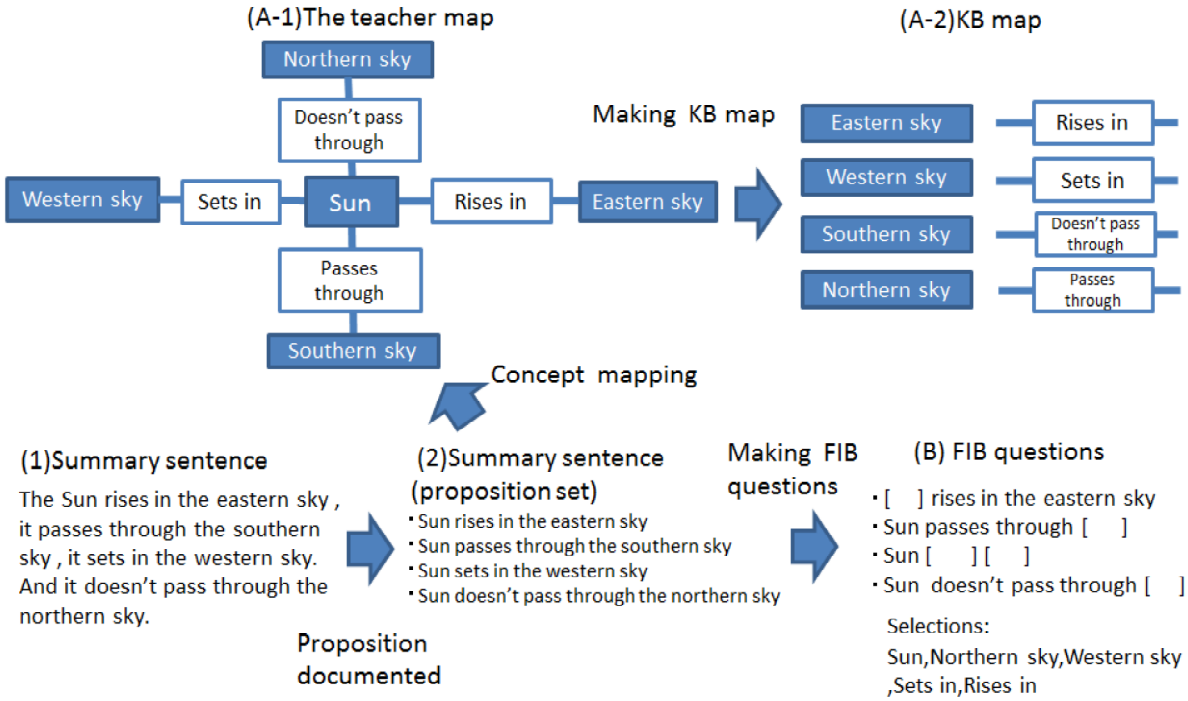

Figure 2 Example of the relationship between KB map and FIB questions

3. Implementation

3.1 Framework of Implementation

Figure 3 shows the framework of the implementation of the system to deal with both KB map and FIB questions. This system has been developed as an extension of the KB System (Hirashima et. al., 2015). Based on this framework, implementation of the system is explained.

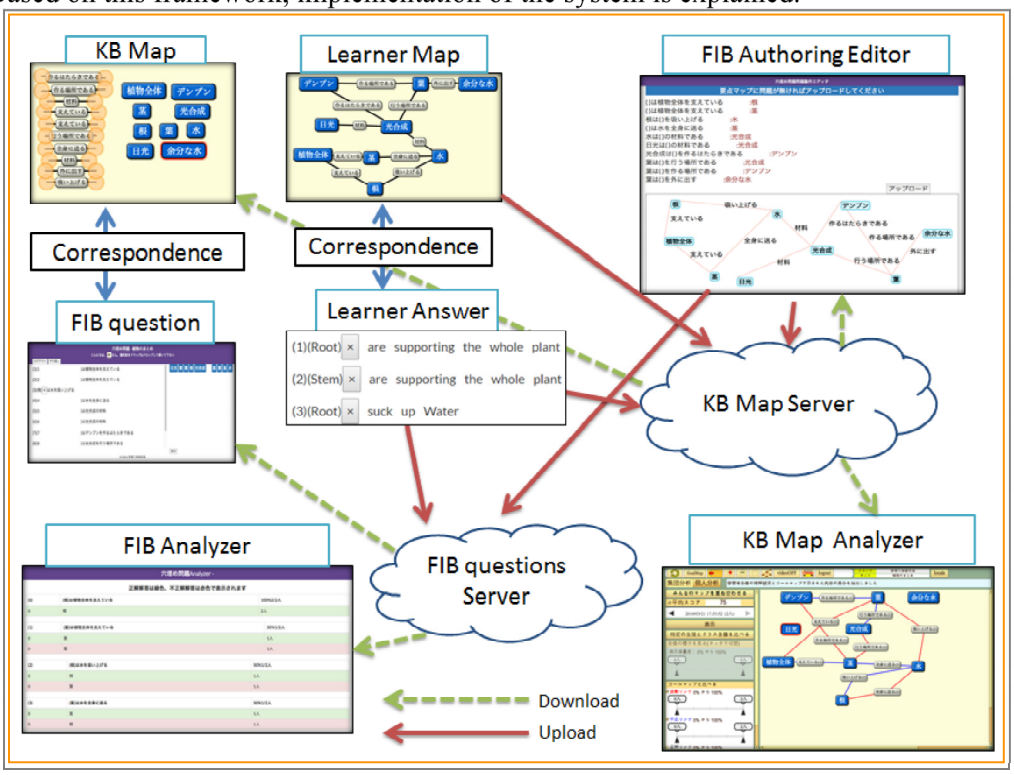

Figure 3 Framework of Implementation

3.2 Authoring Process of KB map and FIB Questions

3.2.1 Making a Set of Propositions and KB map and FIB Questions

Figure 4 shows the process to make a set of propositions. In this interface, a teacher specifies two node words/phrases and one link word/phrase in each sentence. Nodes are marked by "#" and "&", and link word is marked "@". By this marking, it is possible to make a set of propositions automatically. Then, the propositions are directly translated into a concept map shown in Figure 5. The layout of the teacher map is determined automatically and can be modified the layout later as the teacher by drag and drop manipulation of the nodes and links. The teacher map is registered in KB map system and a student is allowed to build a concept map with KB map editor.

3.2.2 Making FIB Questions

From the set of propositions shown in Figure 4, FIB questions are able to generate by specifying the blanks. Figure 6 shows an example of the process. In this case, the first concept in each proposition is specified as the blank. Then, choices for the blanks are given as a set of deleted words to make the blanks. Figure 7 shows answering editor of FIB questions generated by specification shown in Figure 6. In the answering editor, several sentences with blanks are shown in the left side and the set of choices are given in the right column. By drag and drop manipulation, a choice is put into the blank in a sentence. In Figure 7, sentence (4) and (5) are filled the blanks correctly corresponding to propositions.

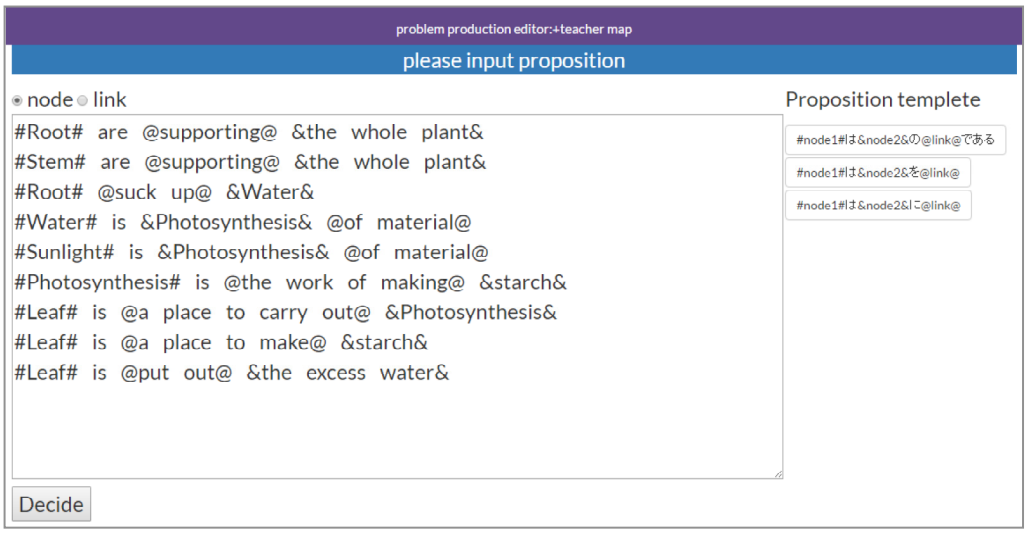

Figure 4 Inputting proposition

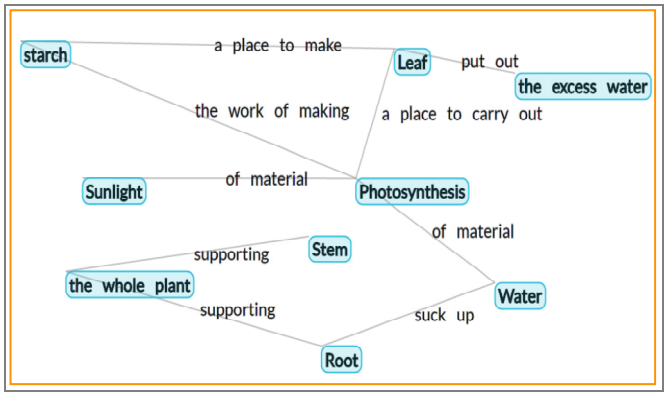

Figure 5 Teacher map that teacher was layout

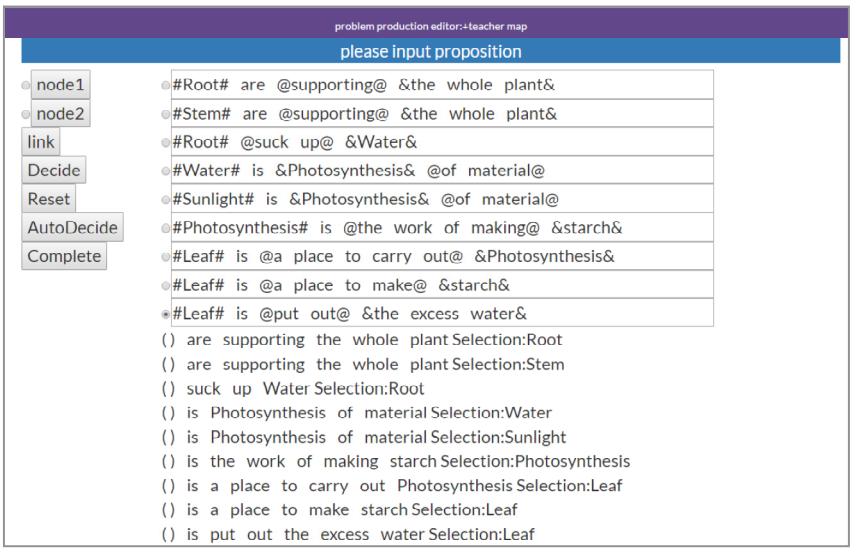

Figure 6 Creating FIB question

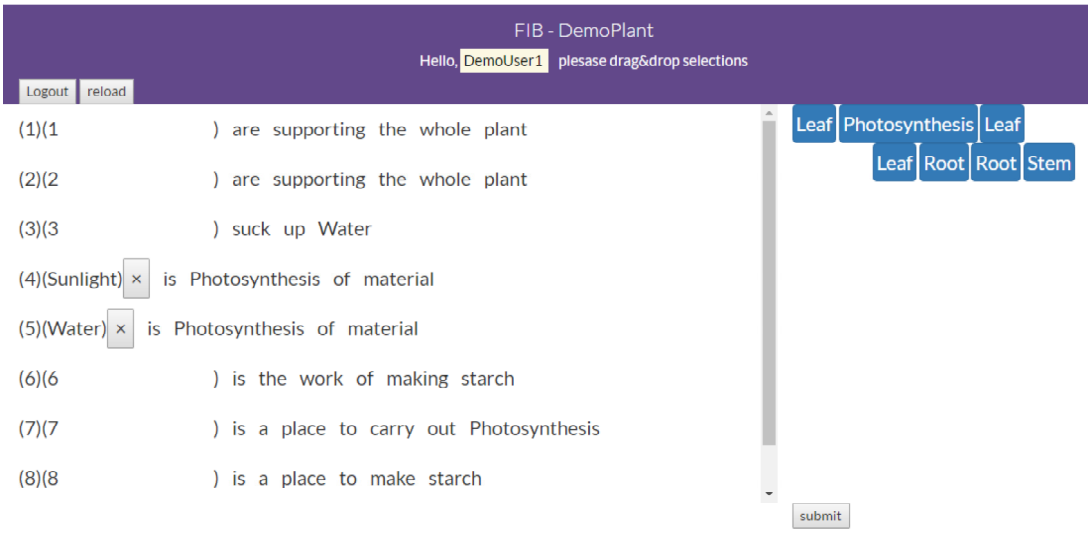

Figure 7 FIB Questions

3.2.3 Analysis of Answers for FIB Questions

A teacher can use an analyzer to check the results of answering as shown in Figure 8. In this analyzer, for each question, the number of correct answers, types of incorrect answers, their numbers, and their percentages for the total answers. The teacher is also able to check each student's answers. Because these questions and answers can be translated into propositions, they can be represented as a concept map. We visualized the results of answering for FIB questions by using KB analyzer as shown in Figure 9. These two figures correspond reciprocally. For an example, Question(A) in Figure 8 was made from the proposition "#Stem# is @supporting@ &the whole plant&" that is at the top of the list of propositions in Figure 4. Then an incorrect answer for the Question(A) corresponds to an incorrect proposition "#Leaf# is @supporting@ &the whole plant&". This mistakenly composed proposition is visualized with red colored link as shown in Figure 9 marked (A1). In KB map, a mistakenly composed proposition is interpreted as an incorrect connection of a link. So, this mistake is called "excessive link". Because the link @supporting@ was used in the wrong proposition, a correct proposition, that is, "#Stem#" is @supporting@ &the whole plant&" is lacking in the answers. So, in the map shown in Figure 9, the lacking proposition is visualized by a blue link marked (A2). We call the link "lacking link". This is a visualization of answers of FIB questions with KB map.

FIB Analyzer -

Correct:Green Uncorrect:Red

(0)	(Root) are supporting the whole plant	100%2/2人
0	Root	2人
(1)	(Stem) are supporting the whole plant	50%1/2人
0	Stem	1人
0	Leaf	1人
(2)	(Root) suck up Water	100%2/2人
0	Root	2人
(3)	(Water) is Photosynthesis of material	100%2/2人
0	Sunlight	2人
(4)	(Sunlight) is Photosynthesis of material	100%2/2人
0	Water	2人
(5)	(Photosynthesis) is the work of making starch	50%1/2人
0	Photosynthesis	1人
0	Stem	1人
(6)	(Leaf) is a place to carry out Photosynthesis	50%1/2人
0	Leaf	1人
0	Photosynthesis	1人

A

Figure 8 FIB Analyzer screen

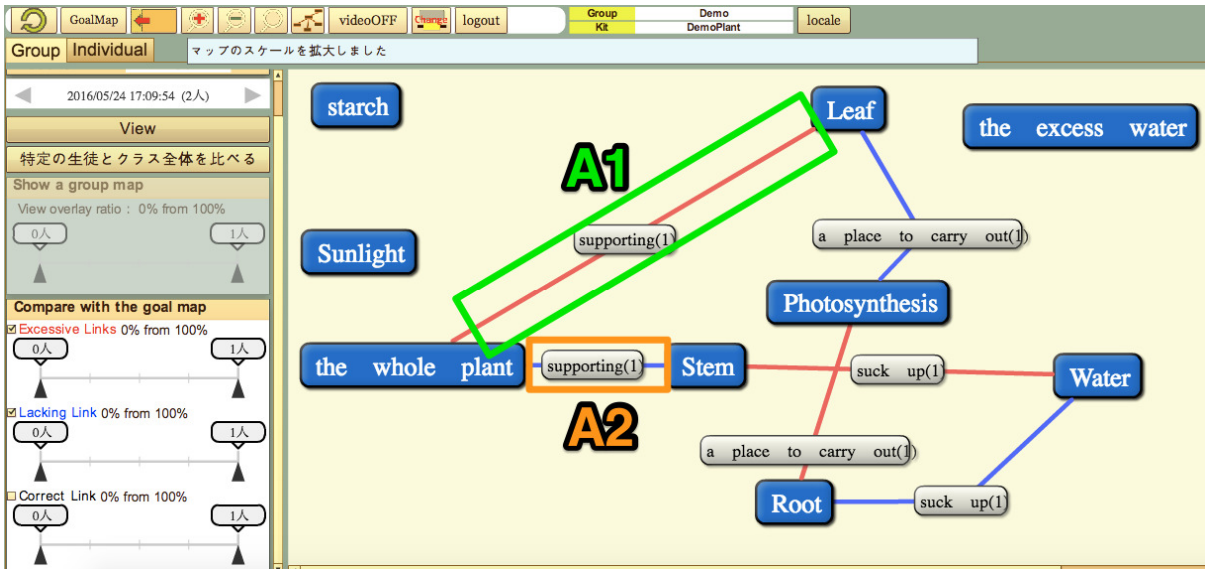

Figure 9 Visualization of Answers for FIB Questions with Concept Map

4. Comparing KB Map Task and FIB Questions Task through a Practical Use

4.1 Practical Use in an Elementary School

In this practical use, two classes of 5th grade students in an elementary school attended. The same teacher taught them three class times. The subject is science and the topic is “plant ecology”. In every

last 10 minutes in each class time, the teacher conducted an exercise to strengthen and confirm students' understanding for the lecture. One class used KB map exercise and we call this class KB class (37 students). The other class used FIB question exercise and we call this class FIB class (37 students). In KB map exercise, a student is requested to build a concept map from provided components. In FIB question exercise, a student is requested to answer several fill-in-the-blank questions by selecting multiple choices. The map and questions are made by the same teacher map. The teacher map made by the teacher corresponds to the lectures. The teacher map is confirmed by another teacher of science in the elementary school.

In order to examine the equivalence of the two groups, we used scores of a general test of science provided by an exercise book used in the elementary school. Full marks were 100. Because there was no significant difference in the scores of the two groups as shown in Table 1, we assumed that the two groups were equivalent in science learning. After all classes of this use, the teacher conducted a post-test that requested the students to answer several questions about the learning topics by description. The post-test was made by the responsible teacher based on the learning topic and marked the teacher. The answers of the questions in the post-test are implied in the propositions but cannot derive the answer directly. So, the questions request a student to understand the meaning of the propositions.

In this practice, KB map exercise and FIB question exercise were carried out three times respectively in each class. The average score of KB map exercises was 79.3(SD=24.4), and then, FIB question exercise was 100(SD=0.0). In KB class, after the exercise, the teacher found several incorrect propositions in the class and gave feedback about the propositions. In FIB class, because there was no incorrect answer, the teacher explained the propositions as important points of the class. Therefore, FIB question exercise didn't detect misunderstanding of FIB class students, and then, the KB map exercise detected misunderstanding of KB class students.

Table 2 shows the results of the post-test. There was significant difference between the score of KB class and FIB class (p=1.17E-13) and the effect size was large (d=0.71). There were statistically significant correlations between the general test scores and the post-test scores in the both groups as shown in Table 1 (r=.63 in FIB class, and r=.59 in KB class). This correlation suggests that the scores of the post-test were reliable. Based on these results we concluded that KB map exercise has better learning effect than FIB question exercise. This result also suggests that FIB exercise was not enough to detect students' misunderstanding.

Table 1 Results of General test (full marks:100) and Post-test (full marks:11)

	General Test(SD)	Post-test (SD)	Correlation between Two tests (p-value)
FIB group	60.0(12.7)	7.2(2.4)	r=0.63(p=3.1E-05)
KB Map group	60.9(15.5)	8.8 (2.1)	r=0.59(p=0.0001)

5. Conclusion and Remarks

We have proposed the kit-building task of a concept map (KB map task) as a promising exercise for strengthening and assessing learner's comprehension for a topic that a learner already has learnt. In this paper, in order to investigate the value of the KB map task, we compare it with multiple-choice task of FIB questions (FIB question task). The multiple choice task of fill-in-the-blank questions is also used to strengthen and assess learner's comprehension, and the answer can be automatically evaluated. Then, the both task can be generated from the same series of propositions, that is, from the same contents. We have compared the two tasks through 3 lessons of science learning of 5th grade students in two classes. One class used KB map (KB class) and another class used Fill-In-the-Blank questions (FIB class). The results suggested that the KB task evaluated learner's comprehension more adequately than the question task and the students in the KB class had higher performance than the students in the question class.

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