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Support for Concept Map Building based on Learner's Building History

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Abstract: In the framework of kit-build concept map, (1) a goal map is prepared by a teacher, (2) parts of the map is generated by decomposing the goal map, and then, (3) a learner makes a map (a learner map) by combining the parts. The learner map is diagnosed by comparing with the goal map. The differences between the learner map and the goal map should be resolved by the learner to complete the learner's map building. In this research, we have investigated a way to support the learner to resolve the differences. Based on the analysis of learner's map building behavior, we have proposed three kinds of hints for learners, that is, (I) concept group-centered building, (II) specific concept-centered building, and (III) recently connected concept-centered building. We have implemented a function to generate these hints based on the learner's building history and conducted a preliminary evaluation of the function.

Keywords: Kit-Build Concept Map, Map Building History, Hint for Map Building

Introduction

Concept map is an useful tool to promote learners to describe their knowledge or understandings by themselves [1]. From the viewpoint of teaching, the concept maps built by learners are promising products to examine the learners' understandings [2-6]. Diagnosis of concept maps built by learners, however, remains as a big issue to realize educational interaction through the concept map. We have already proposed a "Kit-Build Concept Map" as an approach to realize automatic diagnosis of concept maps [7]. In the framework of kit-build concept map, (1) a goal map is prepared by a teacher, (2) parts of the map is generated by decomposing the goal map, and then, (3) a learner makes a map (a learner map) by combining the parts.

In this paper, a way to support the concept map building is explained and an implementation of the support function is introduced. Results of a preliminary experiment of the support function are also reported.

1. Support for leaner's map building

In kit-build concept map, errors of a learner map can be detected by comparing the learner map with the goal map. Because the detected differences should be solved by the learner, the differences are targets of the support. In kit-build concept map, all nodes and links are correct ones. Therefore, the errors in a learner map appear as wrong connections. The wrong connections, then, are classified into two types, one is an "incorrect connected link" and the other is an "unconnected link". In this paper, only the support for unconnected links is dealt with. In kit-build concept map, there is a correct pair of nodes corresponding to an unconnected link. Therefore, as an indication of the pair of nodes, a hint to an unconnected link is given. As for the incorrect connected link, it is necessary to take off the link first and then to connect it correctly. Because the support for an incorrect connected link is advanced one, we consider it for our future work.

Usually, in the diagnosis of a learner map during the process of map building, there are many unconnected links are detected. Therefore, it is necessary to select an unconnected link as the target of the support. Through the analysis of learners' map building, we found three types of typical building behavior, that is, (I) concept group-centered building, (II) specific concept-centered building, and (III) recently connected concept-centered building. Because these three building behaviors are natural, it would be better to promote these behaviors in the support. In the following subsections, the details of the three supports are explained in more detail. Examples of learner's mapping histories and hints are shown in Figure 1. Circled numbers attached to links are the order of which a learner connected. Map building history means the order in this research. Then, a dotted line shows an unconnected link that is a target to support.

1.1 Concept group-centered building

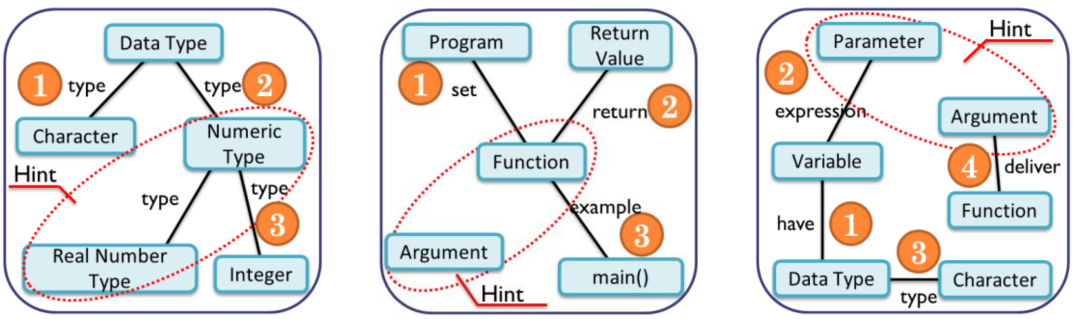
This is a behavior that a learner focuses on building a specific part of a concept map. In this case, it is efficiently for the learner to give a hint which is related to the partial map learner focuses on. Therefore, as a support target, we select an unconnected link which learner do not yet connect in the group. Figure 1a is an example of a specific part of the goal map regarding "data type". The learner has built the leaner map following the circled numbers in order, and then "type" link between "numerical value type" and "real number type" within the part has not been linked yet. Therefore, the group-centered building hint support a learner to add the lacking link ("type" link) between the two nodes. A group in a goal map should be decided by a teacher or domain expert when he/she prepared the goal map.

1.2 Specific concept-centered building

This is a behavior that a learner connects several nodes to a specific node. In this case, suggestion of a node that is connected to the specific node is a useful suggestion for the learner. Figure 1b is an example where a learner is building a map focusing on the node "function". In this case, because "parameter" is able to be connected to "function", linking between "function" and "parameter" is suggested to the learner.

1.3 Recently connected concept-centered building

This is a behavior that a learner connects a new node to the recently connected node. In this case, indication of a node that is able to be connected to the latest connected node is a useful suggestion for the learner. In Figure 1c, the latest connected node is "parameter" and "function". In this case, "type" link that connects "parameter" and "formal parameter" is selected as a hint.



(a) Concept group-centered (b) Specific concept-centered (c) Recently connected concept-centered

Figure 1: Examples of learner's mapping histories and hints.

2. System Outline

In order to realize the above discussion, we implemented the kit-build concept map system. Details of the kit-build concept map system [7] are omitted in this paper.

In goal map building, a teacher builds a goal map first in the same way with previous system. After that, the teacher makes several groups in the goal map. In learner map building, a learner builds a map in the same way with the previous system. When the learner feels difficulty to continue the map building, the learner is able to get a hint by pressing the hint button. The system then selects and provides a hint based on the learner's map building history. Figure 2 shows an example of a hint given to a learner.

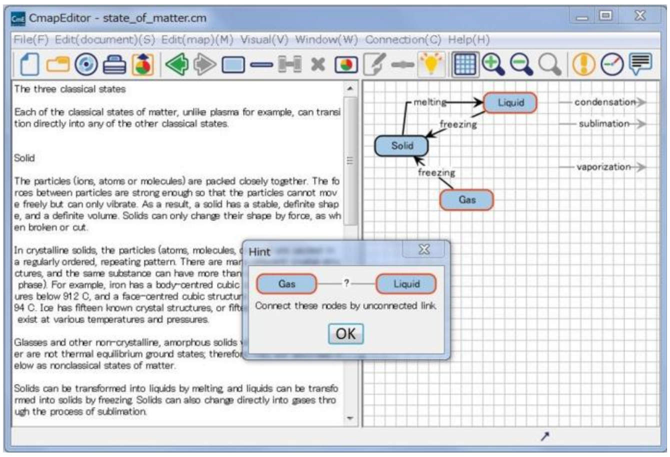


Figure 2: Example of a hint given to a learner.

3. Preliminary evaluation

3.1 Method

Participants of the experimental use of kit-build system were 31 university students. They were randomly divided into 2 groups. In the beginning of the experimental use, each of them builds a small learner map based on the same learner material as a practice of the use of the system which doesn’t include the hint giving function. After the practice, all of them were asked to build larger learner maps without the hint giving function. The building time was 30 minutes. At this time, one group consisting of 15 participants (Group 1) built learner maps of a learning material "Material-A: Cells of living organisms", and the other group consisting 16 participants (Group 2) built learner maps of another learning material "Material-B: Physical structure of plants". After this building phase was over, they were asked to answer questionnaire. After all students answered, they were asked to build learner maps in the system with the hint giving function. The building time was also 30 minutes. At this time, the target materials of the learner map building were exchanged in the groups. After the building time, they were also asked to answer the questionnaire including several questions as for the hint giving function.

3.2 Learning materials

The learning material of the practice "Circulation of water" consists of 282 Japanese letters with 3 paragraphs. Kit is composed of 27 parts (11 nodes and 16 links). Material-A "Cells of living organisms" is composed of 947 Japanese letters with 4 paragraphs, and then the kit is composed of 63 parts (24 nodes and 39 links). Material-B “Physical structure of plants" is composed of 965 Japanese letters with 5 paragraphs, and then the kit is composed of 58 parts (27 nodes and 31 links).

3.3 Results and discussion

We first paid attention to the frequency of using hints in the system use. When a participant who pressed the hint button carried out the following three behaviors after receiving the hint, we judged that the hint contributes to participant's map building, that is, [i] connecting the presented part right away, [ii] connecting the presented part after disconnecting the link already connected to the presented part with the hint, and [iii] connecting the presented part after connecting other parts that were in the same relation as the presented part with the hint. The results are shown in Table 1. The hints were used for 139 times in total: 81 times for Material-A and 58 times for Material-B respectively. The number of hint uses per a participant is 4.48 times in average. This result suggests that the hint giving function was actually used by the learners. Then, 109 hints (78%) are judged that they contributed to the map building.

Table 1: Frequency of hint use

	Number of hint use		Number of effective hint		Rate of effective hint
	Total	Average	Total	Average	
Material A	81	5.06	61	3.81	0.75
Material B	58	3.87	48	3.20	0.83
Total	139	4.48	109	3.52	0.78

In order to evaluate the hint giving function, differences in the learner map building with /without hints were examined. The results are shown in Table 2 and 3. Since the sizes of goal maps were different in the learning material, the data of incorrectly connected and unconnected links were normalized. Since there was normality in the building time data, the paired *t*-test was applied to it and a significant trend was confirmed with the result being $p = 0.074 < 0.10$. Since there was not normality of data of incorrectly connected links and unconnected links, the Wilcoxon signed-ranks test was carried out. The result for incorrectly connected links was $p = 0.571 > 0.10$, showing no significant difference. On the other hand, the result for unconnected links was $p = 0.044 < 0.05$, showing a significant difference. Based on the above-mentioned results, the building time tended to be decreased by giving hints. Then, it also suggested that unconnected links have decreased by giving hints. Although no significant difference was recognized for incorrectly connected links, it was reasonable because the incorrectly connected links were not treated as the target of hint giving in the current system.

Table 2: Results of the experiment

Hint	Material	Creation time		Incorrectly connected link		Unconnected link	
		Average : min.	Average per a part : sec.	average	Ratio of incorrectly connected links	average	Ratio of unconnected links
Without (N=31)	A	24:43	23.53	1.73	0.044	0.93	0.024
	B	25:31	26.40	5.25	0.169	0.50	0.016
With (N=31)	A	22:46	21.70	1.19	0.030	0.13	0.003
	B	24:54	25.76	4.27	0.138	0.13	0.004

Table 3: Statistical analysis

Hint	Creation time		Incorrectly connected link		Unconnected link	
	average	standard deviation	average	standard deviation	average	standard deviation
Without	25.012	3.7842	0.1089	0.1050	0.0199	0.0474
With	23.664	4.4230	0.0823	0.0879	0.0037	0.0098
p	0.074		0.571		0.044	

We asked participants questionnaires, that is, (A) Total of question results with regard to Material A, (B) Total of question results with regard to Material B, (C) Regarding map creation, (D) Regarding hints in general, (E) Regarding influence on memory, (F)

Regarding the presence/absence of hints. The extract of the results of questionnaire are shown Table 4. It seems that participants could adequately think about the presented hints, because many positive answers are found in D1-D4. It is understood from the results of F1 and F2 that participants felt the map building is easier when hints are provided.

Table 4: The extract of the result of questionnaire

	4	3	2	1
D1. Reading the presented hint made me understand which node to consider.	16	10	4	1
D2. After thinking enough about the presented hint, I could connect with the links.	15	8	5	3
D3. I could understand (think about) the reason why that hint was presented.	8	14	7	2
D4. The presented hint served as references for me to create other parts of the map.	11	14	5	1
F1. It is easier to create maps without hints presented.	3	3	13	12
F2. It is easier to create maps with hints presented.	16	11	3	1

In conclusion, validity of the hint giving function were suggested by the following four results: (1) the frequency of the hint used by the participants, (2) the analysis of the participants' behaviors after receiving hints suggest, (3) comparison between two systems with hints and without hints concerning "building time" and "number of unconnected links", and (4) results of the questionnaire.

4. Conclusions

We have continuously investigated kit-build concept map building and have already implemented a learning environment with the kit-build concept map. In this paper, we have proposed three kinds of hints to support a leaner to build his/her concept map, that is, (I) concept group-centered building, (II) specific concept-centered building, and (III) recently connected concept-centered building. The function has been implemented within the existing learning environment and experimentally evaluated. The results suggested that the function is promising to help a learner to build his/her concept map fast and precisely. Although this is a case study currently, it would be possible to extend this approach.

As part of future work, deeper analysis of learner's behavior of map building is very important. In kit-building concept map, all parts used in the building process are the same ones with learners and teachers. Therefore, it is possible to compare other learners' or ideal one. By using these characteristics of kit-build method, we will examine the map building process in more details and design more suitable support for each learner.

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