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A COACHING ALGORITHM FOR BUG MODIFICATION ON THE LEARNER'S CONCEPT MAP

Makoto Takeya and Satoshi Tomita
Takushoku University
Email: {takeya@cs, y7m316@st} @cs.takushoku-u.ac.jp

Abstract. It is very important both to evaluate understanding level of a learner's structural knowledge and to coach the learner to correct his or her misunderstanding. This poster presents the Concept Mapping Test method (*CMT*) as a measurement tool of structural knowledge. In the *CMT*, the learner's structural knowledge is described by a Concept Map (*CM*), which can be compared to that of the teacher. Firstly the authors will present a quantitative evaluation method for structural knowledge in individual learners. Secondly, they will present a modification algorithm for bugs in the learner's structural knowledge in order to assist individual learners. Thirdly, they will discuss a case study of the *CM* assembled for a one-dimensional slider in the Design and Drafting course of our University and show validity for its *CMT* utilization.

1 Introduction

When a learner acquires content on the learning system, what has been gained is arranged in a linear or sequential order. Each unit is presented in order. That is, they move naturally from one idea to the next without ever systematically detailing the structural relationships among these ideas. The teacher is concerned with assessing and promoting the acquisition of knowledge by individual learners. Attention has recently focused on what has become known as structural knowledge or knowledge of interrelationships among ideas in their knowledge domain. It is important to establish the internal connectedness of ideas and concepts to be learned. It is difficult to evaluate the internal relationships among ideas by using traditional poster tests, because these tests mainly measure the understanding level of individual bits of knowledge obtained by individual learners.

The authors earlier presented the Concept Mapping Test method (*CMT*) as a measurement tool of structural knowledge (Takeya, 1999). In the *CMT*, the learner's structural knowledge is described by a Concept Map (*CM*), which can be compared with a teacher's *CM*. They began with a presentation of both a new way to measure differences between a pair of maps (Takeya et al., 2004). It also shows a performance scoring method based on concept maps drawn by individual learners compared to a concept map drawn by the teacher (Takeya et al., 2006). This poster presents an evaluation method for *CMT* and the modification algorithm for bugs in the learner's structural knowledge in order to assist individual learners. Here, bugs are defined as a learner's misunderstanding of the relationships among learning objectives. Also, this poster discusses a case study on the *CM* assembled for a one-dimensional slider in the Design and Drafting course of our University and shows validity on its *CMT* utilization.

2 An evaluation method for *CMT*

Following is a discussion of a Concept Mapping Testing method by using the *CM*, instead of the traditional formative test, to do a formative evaluation from different angles (Takeya et al., 2004; Takeya et al., 2006). The logical flow is a kind of concept map, the edges of which have a single meaning of relationship, such as prerequisite relationship. The concept mapping testing involves individual learners drawing their concept map, called logical flow under restricted conditions. The *CM* can be represented by a digraph (directed graph) $G = (V, E)$, where V represents a set of concept elements (vertices) and is composed of n elements (vertices), and E represents a set of ordering relations (arrows) and is composed of m ordering relations (arrows). Here, the arrow $a \rightarrow b$ represents the ordering relation where element a is a necessary prerequisite to element b .

The *CM* may be used as follows:

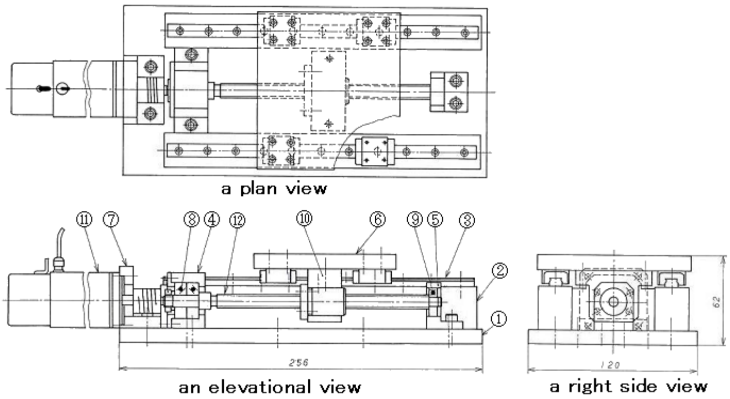
1) The teacher may draw the *CM* $G_T = (V, E_T)$ according to the contents of the test to be presented.

2) After learning on the subject, the teacher may give the *CMT* to draw each learner's *CM* $G_S = (V, E_S)$ with elements which are equal to those of the teacher's *CM* drawn in 1). Note that the arrow → has a unique meaning, *i.e.* a prerequisite relation, cause and effect relation, influence relation, etc. By this restriction, it is possible to measure the degree of similarity between a pair of *CM*s quantitatively, in comparison with the traditional Novak's maps. The test can specify in advance that the *CM* is composed of n concept elements (vertices), some elements included in n elements are initial concept(s) and a target concept and the meaning of ordering relationship (arrow). Individual learners have to draw their *CM*s, arranging the rest concept elements and drawing adequate ordering relationships, *i.e.* arranging the rest vertices and drawing appropriate arrows.

3) The teacher can compare individual learners' maps with their own, measure the structural concept levels of the individual learners, and coach the learner according to the coaching algorithm.

Describe the assembly process of a linear slider by LFG using all the following specified parts, making reference to the assembly diagram. Here, part ⑪ DC motor and ⑫ Ball screw are initial prerequisite elements and part ① Base should be taken as the final objective item.

Part number	Name of parts	Part number	Name of parts	Part number	Name of parts
②	Guide frame	⑤	Support unit Ⅱ	⑧	Angular contact ball bearings
③	Linear guide	⑥	Table	⑨	Deep groove ball bearings
④	Support unit Ⅰ	⑦	Motor bracket	⑩	Nut folder



Answer

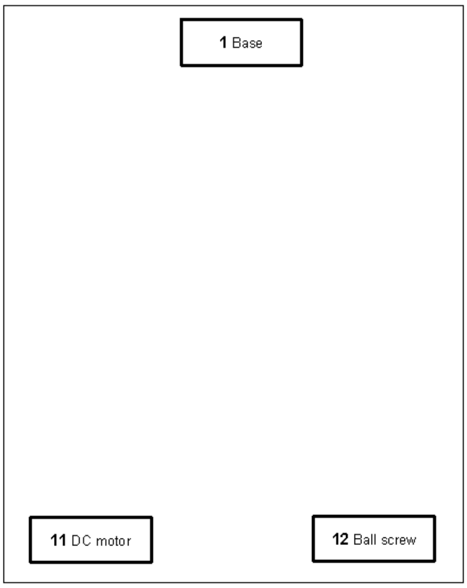


Fig.1 The *CMT* sheet on a liner slider in Design and Drafting course.

Note that individual vertices on each learner's map are the same as the ones on the teacher's map so that the teacher can evaluate how much individual interrelation of ideas was taught through the lectures. It follows that the discovery of their differences should be useful in conveying structural information to the learner. A *CM* drawn by the teacher serves as a teaching tool that allows that teacher to communicate to the learners the interrelatedness of ideas in the knowledge domain. The *CM* produced by the teacher presents learners with a graphical synopsis of the structural relationships among ideas. Comparison of *CMT*s among their maps can supply the degree of the learners' structural knowledge, an understanding that is missing in traditional tests. Discussions of *CM*s allow learners to review their own structural knowledge level. The learners are able to consider their misconceptions of relationships among ideas. The teacher is also able to extract not only misunderstandings in structuring the learners' knowledge, but also to see the deficiencies in communicating or teaching structural knowledge to learners. In order to present our measurement of similarity between two *CM*s, a similarity $S(G_S, G_T)$ between two digraphs $G_T = (V, E_T)$ and $G_S = (V, E_S)$ was defined by Takeya and *etc*.(2006).

3 A modification algorithm of learner's bugs on the *CM*

Firstly, we will present several definitions. A logical path *LP* is defined as a path on Graph Theory, with restricted conditions where a start and an end vertex belong to an initial vertex and a terminal vertex, respectively. This modification is based on edge difference focused on the most similar *LP* between teacher's and learner's *CM* in order.

Secondly, we define m *LP*s included in $G_T = (V, E_T)$ by P_T^k $(k = 1,2,\cdots,m)$. In the same manner, we define m_i *LP*s included in $G_S^i = (V, E_S^i)$ that are modified by $P_S^j(i)$ $(j = 1,2,\cdots,m_i)$ $(i = 1,2\cdots)$. Next, pay attention to both m *LP*s P_T^k $(k = 1,2,\cdots,m)$ and m_i *LP*s $P_S^j(i)$ $(j = 1,2,\cdots,m_i)$ $(i = 1,2\cdots)$. Each *LP* P_T^k and $P_S^j(i)$ can be represented by $G_T^k = (V, E_T^k)$ and $G_S^j(i) = (V, E_S^j(i))$ respectively. Here, E_T^k and $E_S^j(i)$ are included in P_T^k and $P_S^j(i)$ respectively. Now, let's define sets of *LP*s on $G_T^k = (V, E_T^k)$ and $G_S^j(i) = (V, E_S^j(i))$ by $\prod(P_T)$ and $\prod(P_S(i))$, respectively.

As a result, we can now describe the modification algorithm for individual learners' bugs.

(1) $i = 0$;
If $E_S^j(i)$ is equal to E_T^k, then go to (7).

(2) Obtain a *LP* $P_S^{j_M}(i)$ that satisfies both $S(G_T^k, G_S^j(i)) < 1$ and $Max_{\prod_T, \prod_S(i)}\ S(G_T^k, G_S^j(i))$. This is $G_S^{j_M}(i) = G(V, E_S^{j_M}(i))$.

(3) If $\overline{E_T} \cap E_S^{j_M}(i) \neq \phi$, then suggest the deletion of a set of edges $\overline{E_T} \cap E_S^{j_M}(i)$.

(4) If $E_T^k \cap \overline{E_S^{j_M}(i)} \neq \phi$, then suggest the addition of a set of edges $E_T^k \cap \overline{E_S^{j_M}(i)}$.

(5) If $E_S(i) = E_T$ and proceed to (7).

(6) $i = i+1$; Proceed to (2)

(7) End.

4 Case study of guidance based on the coaching algorithm

To help you understand our *CMT* easily, we will examine the case study of a *CMT* following both learning and CAD lessons of the System Design Course of our University. An example of the *CMT* sheet on a liner slider in Design and Drafting course is shown in Fig.1. Here, the element (vertex) on the highest level is only the element (1). The elements (11) and (12) belong to the lowest level as shown in Fig.1. Each learner has to place a set of elements (3)-(10) between the highest and lowest levels and then draw directed edges. Fig. 2 shows (a) the *CM* drawn by the teacher and (b) the *CM* drawn by one of the learners. In Fig.2 (a), for example, as the role of (7) motor bracket is to decide the height of (11) the DC motor and to support it, an arrow is drawn from (11) to (7). In the same manner, as (7) motor bracket is fixed on (1) base, an arrow is drawn from (7) to (1). According to the modification algorithm described in 3, Fig.3 shows a modification process of a learner's *CM* to the teacher's *CM* in Fig.2. Here, a broken line and a heavy line show deletion of the arrow and addition of the arrow, respectively. For example, the Step 1 in Fig. 3 indicates that the teacher has to guide the learner to realize his or her misconnection from (7) motor bracket to (8) Angular contact ball bearings and new connection from (7) to (1). In the next step, the teacher has to make the learner notice new connection between (12) Ball screw and (8) Angular contact ball bearings. A detailed discussion has been omitted due to lack of space. Details of coaching results will be presented on our poster.

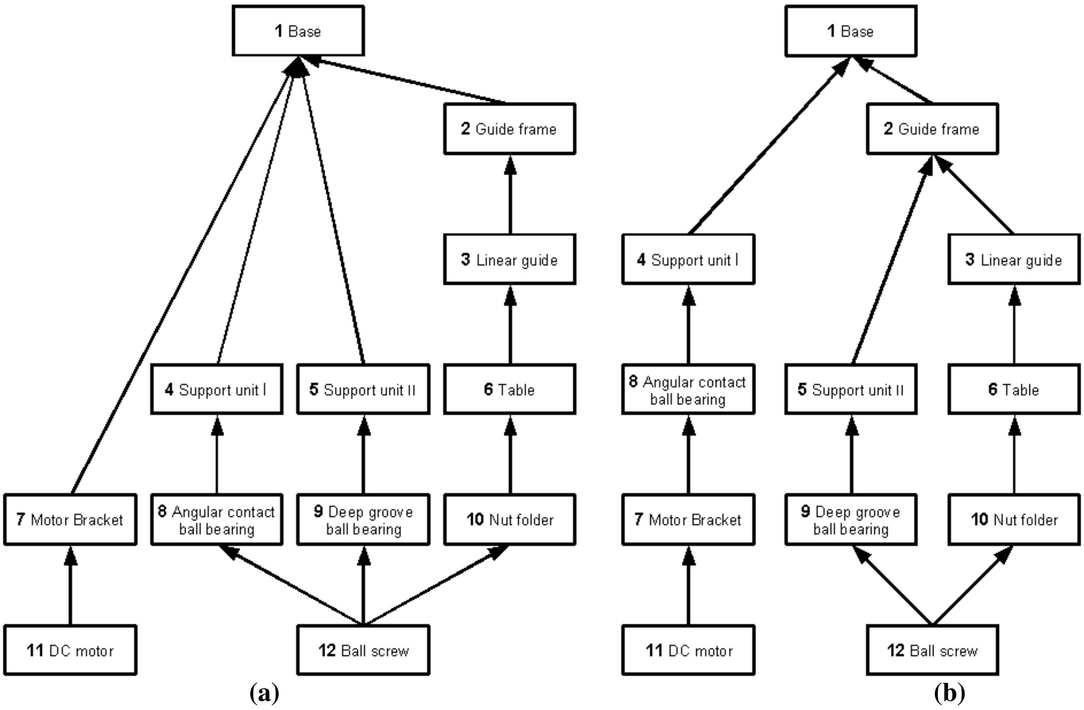


Fig.2 The *CM*s drawn by the teacher and one of the learners.

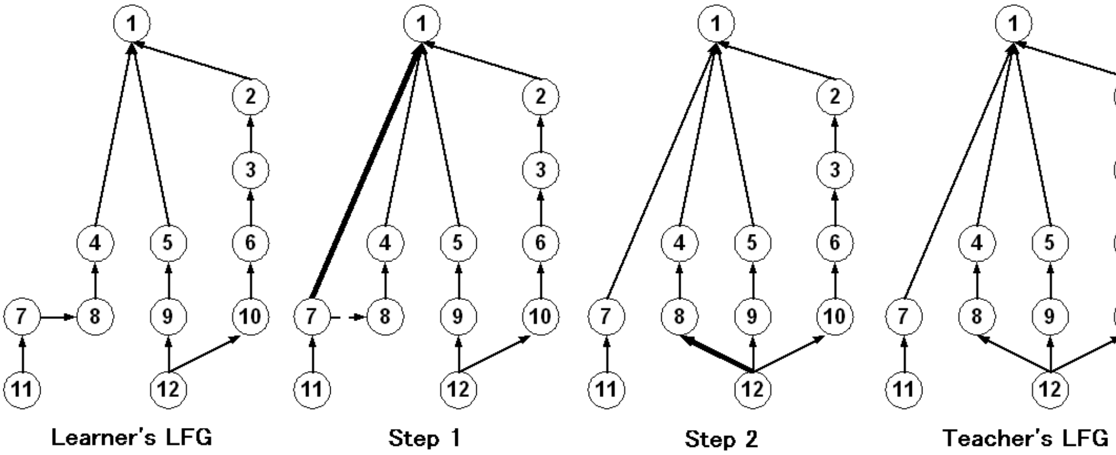


Fig.3 The modification process from the learner's *CM* to the teacher's *CM* in Fig.2.

References

Takeya, M. (1999). Structure analysis methods for instruction: Theory and practice of instructional architecture, design and evaluation, Takushoku University Press, Seizansya.

Takeya, M., Sasaki, H., Nagaoka, K., & Yonezawa, N. (2004). A performance scoring method based on quantitative comparison of concept maps by a teacher and students, Proc. of the 1st Int. Conf. on Concept Mapping, 2, 343-346.

Takeya, M., Yasugi, N., Funabashi, Y. and Nagaoka, K. (2006). Measurement and evaluation method for a concept mapping test by drawing ordering relations among concepts, Proc. of the 2nd Int. Conf. on Concept Mapping, 2, 188-191.