A New Structural Knowledge Assessment Based on Weighted Concept Maps

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Abstract

Concept maps have been widely put to educational uses. But concept maps in the past were limited in their assessment standards. Some only take concept nodes into consideration; other evaluation criteria use concept nodes as the basis, with relation links playing a minor role. To address this problem, this study proposes a new style of concept map, called weighted concept map, which assigns a weight to each proposition in a concept map to represent its importance. This study proposes a new assessment with qualitative comparison founded on a weighted concept map.

Keywords: Concept map, assessment, weighted concept map.

1. Introduction

It has been over twenty years since Novak proposed the idea of concept map in 1971, but researchers are still impressed by its versatile application in curriculum design (Moen and Boersma, 1997; Nitsky, 1998;), teaching strategy (Chang, Sung, and Chen, 2001), and evaluation of teaching (Beyerbach and Smith, 1990; Chen, Lin, and Chang, 2001; Goldsmith, Johnson, and Acton, 1991; Novak and Gowin, 1984). A concept map consists of a set of propositions, which are made up of a pair of concepts (nodes) and a relation (link) connecting them. Such as Figure 1, there are propositions in the concept map, (Main memory include ROM), (ROM may Read), or (ROM may not Write). A concept map is a description of how propositions are organized. Concept maps can reflect how ideas, opinions, and propositions are organized in the knowledge structure of students who construct the concept maps (Jonassen, 2000), and give observations on students’ states. Using the observations as the basis can assess the knowledge structure of students (Novak & Gowin, 1984).

Fig. 1. An example of concept map

A proposition is the smallest unit in the constitution of knowledge (Anderson, 1983;). But in the past, there did not seem to have a convincing standard for assessment based on propositions. For example, Novak and Gowin (1984) assessed students’ concept maps with four scoring principles: proposition, hierarchy, horizontal link, and exemplification. Although they gave different scores according to different principles, they still relied on proposition too much in general. The idea of fuzzy closeness index proposed by Chang et al. (Chen, Lin, and Chang, 2001) makes its assessment based on concepts but also partly based on links. Still, the assessment criteria do not take a whole proposition into consideration. To address this problem, this study proposes the idea of a concept map with weighted propositions and its assessment method.

In the next section, we begin with explaining the idea of weighted concept maps and students’ learning states. Then we propose a comparison method founded on a weighted concept map. The degree of similarity between the knowledge structures of students and experts will be quantified into a value called S index.

2. Weighted Concept Map

Mislevy and Gitomer (1996) argued that the importance of each proposition is different; some of them are specially emphasized in student learning. Teachers need to determine the importance of each proposition based on their professional knowledge, and each proposition is given a weight ranging from 0 to 1. A concept map whose focus is on propositions with weights is what we call a “weighted concept map.” If a proposition ranks high in importance in the given knowledge subject, then it is assigned a high weight, and vice versa.

3. Assessment

To understand how well a student knows a given knowledge subject, we need to invite a teacher to draw this concept map of the knowledge subject. The product is called the expert concept map. Then the concept map drawn by the student was compared with the expert concept map, and the student’s comprehension of each proposition could be determined from the result of the comparison. A student’s comprehension of each proposition as determined after the comparison is one of
the following learning states: the proposition is learned, partially learned, unlearned, or the student has misconception about the proposition.

Let \( G_e(V_e, E_e) \) be an expert concept map; \( V_e \) be a set of concept nodes, and \( E_e \) be a set of relation links. If \((v_i, v_j) \in V_e \) then \((v_i, e_{ij}, v_j)\) represents a proposition in \( G_e \) if the relation link \( e_{ij} \) is connected to two concept nodes \( v_i \) and \( v_j \). Any proposition \((v_i, e_{ij}, v_j)\) can be compared with the propositions in a student concept map. According to the comparison results, it is possible to decide if the proposition \((v_i, e_{ij}, v_j)\) is learned, partially learned, unlearned, or the student has a misconception. The following procedure is how the comparison is carried out:

1. If there is a proposition \((v_i, e_{ij}^*, v_j)\) in the student concept map, then
   (i) \( e_{ij}^* = e_{ij} \), \((v_i, e_{ij}^*, v_j)\) is learned.
   (ii) \( e_{ij}^* = \emptyset \), \((v_i, e_{ij}^*, v_j)\) is partially learned.
   (iii) \( e_{ij}^* \neq e_{ij} \), the student has misconception about \((v_i, e_{ij}, v_j)\).

2. If there is a proposition \((v_j, e_{ij}^*, v_i)\) in the student concept map, then
   (i) \( e_{ij}^* = e_{ij} \) or \( e_{ij}^* = \emptyset \), \((v_i, e_{ij}, v_j)\) is partially learned.
   (ii) \( e_{ij}^* \neq e_{ij} \), the student has misconception about \((v_j, e_{ij}, v_i)\).

3. If \((v_i, e_{ij}^*, v_j)\) or \((v_j, e_{ij}^*, v_i)\) does not exist in the student concept map, then it means \((v_i, e_{ij}, v_j)\) is not learned.

In order to quantify the similarity between the student and the expert concept maps, we score propositions according to the student’s learning state for the propositions.

If proposition \( v_{p_i}^* = (v_i, e_{ij}^*, v_j) \) constructed by the student is a correct one, \( v_{p_i}^* \) is scored by the weight on the corresponding proposition defined in the expert concept map. If the student’s proposition \( v_{p_i}^* \) is partially correct, \( v_{p_i}^* \) is scored by half of weight on the expert’s proposition. If \( v_{p_i}^* \) does not belong to either of the types mentioned above, this proposition is scored no point.

By applying the principles above, we can define \( score(v_{p_i}^*) \) as the score assigned to the proposition \( v_{p_i}^* \). The formula for calculating \( score(v_{p_i}^*) \) is one of the three following conditions. Assume that \( v_{p_j} \) is a proposition in the expert concept map and \( w(v_{p_j}) \) is its weight.

1. If \( v_{p_i}^* \) is a correct proposition, \( score(v_{p_i}^*) = w(v_{p_j}) \).
2. If \( v_{p_i}^* \) is a partially correct proposition, \( score(v_{p_i}^*) = \frac{1}{2} \times w(v_{p_j}) \).
3. If \( v_{p_i}^* \) is neither a correct proposition nor a partially correct proposition, \( score(v_{p_i}^*) = 0 \).

After calculating the scores for all student propositions, we define \( S \) index as the following:

\[
S = \frac{\sum_{i,j} score(v_{p_i}^*)}{\sum_{i,j} w(v_{p_j})} \quad 0 \leq S \leq 1
\]

The \( S \) index is used to explain how similar the student’s knowledge structure is to the expert’s. The larger the \( S \) index is, the more similar the student’s knowledge structure is to the expert’s, and vice versa.

4. Conclusions

This study suggests that the idea of weighted concept map be used as the criteria for assessment. Furthermore, this study proposes a comparison method with weighted concept maps. The students’ concept maps are contrasted against expert concept maps to find out students’ learning states, and then indices are given to students according to their learning states for a given proposition. That will help students construct their concept maps.

Reference