Measuring the Consistency of Concept Abstraction and Similarity of Concept Map from Discussion Database in the PBL Learning Environment

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Abstract: *Students can acquire knowledge with different learning models. The new concepts will store in short-term memory at first. After integrating new concepts with old ones, human brain will make them become long-term memory. The concept map uses the concept and it's hierarchy to present knowledge in learner's brain that he has learned. Teachers should adjust the pedagogical method based on the student's concept map. In this paper, we try to visualize the concept map stored in the student's mind according to the discussion database built-in the PBL Learning Environment that developed in our previous researches, called PBIALS. Through a manipulatable representation way teachers can have a view to know the consistency and lacks of concepts between students and teachers. Teachers can adjust him/her teaching strategies and provide supplemental materials to students according to the mechanism of measuring the consistency and similarity of concept maps between students and teacher designed by this paper.*
Keywords: PBL, Concept Map, Teaching Strategy, Brainstorm Map, Concept Similarity

1. Introduction

What do students think in their mind? And how does teacher evaluate what students know? Because of students may memorize the same facts/lectures, however, the relations among those concepts are totally different. The concepts can not be seen as knowledge without taking the linkage between concepts. The knowledge stored in the long-term memory of students can be only evaluated as right or wrong with test and can not be the pedagogical reference to teacher. Once again, due to the differences between learning strategies, some learning theory such as PBL can not allow teachers to get the students' mind model after a test. (Barrows & Tamblyn, 1980) Therefore, in this paper a suitable mechanism is designed for providing teachers that the students' model just after the discussion and before the test.

To teacher, to get the concept hierarchies of students are much more important than just test what concepts that students had memorized. *Concept map* simulation could present what is the concept hierarchy of students.(Novak, 1981) The concept map can help teacher to know what is the lack of concepts, and the inconsistency stored in the concept hierarchy. And teacher can adjust his/her teaching strategies based on the information provided by the feedback system in which translate the discussion database to Concept Maps; represent the Concept Map with tree-form; and manipulate the Concept Map.

In this paper, the concept map developed with PBL is talked by Section 2. Section 3 analyzes how to simulate concept map with treelike-form from translate the traditional discussion database in the PBL environment such as *PBIALS*. In section 4, the feedback system and algorithms are presented and used for concept processing and feedback generating to teacher. The experiment system is constructed in Section 5. Section 6 makes a simple conclusion and possible future works.

2. Concept Map in PBL

Before proposing the tree-like concept map, there are several terms such as *Problem-Based Learning* (PBL for short), *Brainstorm Map* in PBL and Concept Map should be introduce previously. The definition of PBL is made by Barrows and Tamblyn in 1980 which is that "PBL is a learning experience for students to solve the problems in learning environment." In the PBL learning environment, teacher is just a facilitator in the teaching process (Duch, 2001). Teacher should motivate students to think and let students learn new knowledge. In general speaking, there are four major features in PBL theory as following (Savery & Duffy, 1995):

1. Learners will develop a new cognition with the goal (real world problem).
2. The problem proposed by teacher is related to learner's real-life.
3. The problem or teacher could stimulate learners in learning.
4. Teacher is just a facilitator to learners whom will be trained to develop their problem solving abilities.

Students will develop their problem solving abilities with the questions which proposed by teacher in PBL learning environment (Beyer, 1988).

In the PBL learning environment, the questions/problems proposed by teacher in class should make students to think the question repeatedly (Hmelo & Ferrari, 1997). The questions should be interrogative, such as "Are you sure?", "Could you prove the answer is correct?" And then, students will communicate with other classmates in a small group and draw the brainstorm map via discussion in the brainstorm time.

Therefore, the concepts about the question will be presented with the form of Brainstorm Map concretely. Teacher evaluates students' concepts with the Brainstorm Map which students drawn to answer the question. Hence, the Brainstorm Map could be viewed as the learning effects or learning results which are able to give the understandable feedbacks to teacher in order to adjust his/her teaching strategies depend on students' Brainstorm Map. With the PBL learning environment students will get more information from the problem related to real world (Chen, et al., 2003; Hoffman & Ritchie, 1997; Sage, 2000). And Brainstorm Map could let students creating much more comments.

Although Brainstorm Map can represent the concepts which students had learned, the concept map is much easier for teacher to understand and measure students' learning effects. The Concept Map is brought up by Novak in 1981, the concept map is used to present the answer and the meanings of question (Novak & Gowin, 1984; Oblinger, 1992). The concept map is constructed to present what students think in their minds, and help teacher to check what the lacks of concepts students might need.

Teacher could explain his/her teaching materials systematically and sequential with concept map and present what the teaching content in the form of concept map (Turns & Adams, 2000). Concept map is a semantic description of the concepts and can do what ever the brainstorm map can do, which is much more hierarchical than the brainstorm map and much easier for teacher to interpret as mentioned previously. Therefore, the concept map will be taken into our consideration in designing the mechanism of measuring the consistency and similarity in this paper, and the next Section will analyze the tree-like concept map which translated from the discussion database.

3. Analysis of Teaching Strategies with Tree-like Concept Map

In the discussion stage of the PBL learning environment, students will keep modify their own Brainstorm Map as Figure 1 shown below.

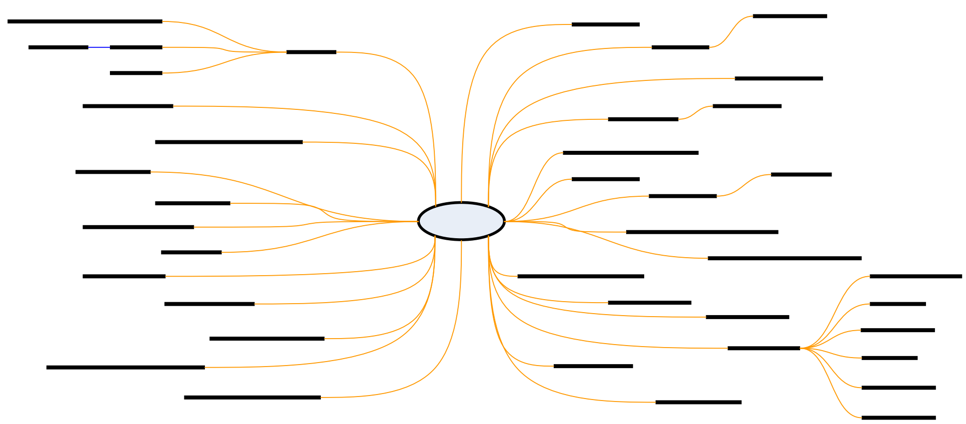

Figure 1. Brainstorm Map

The brainstorm map is hard for teachers to check if the concepts in student's mind are either correct or partial correct since the brainstorm map is too complex to understand. Hence, before we can develop the mechanism to measure the consistency and similarity between student and teacher, the related brainstorm map should be translated to the concept map first. Figure 2 demonstrates the process of constructing the brainstorm map in the PBL environment.

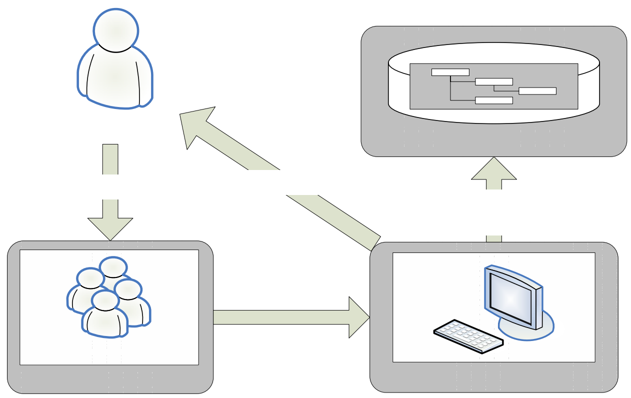

Figure 2. Brainstorm Map in the PBL Learning Environment

The brainstorm map which constructed by students in the PBL learning environment is stored in a built-in discussion database as Figure 2 shown above. Before we can measure the consistency and similarity of concept maps between students' and teacher's, the brainstorm map is needed to translate to the tree-like concept map. Figure 3 represents the related processes of translation, replaying and bending. At first, the concepts and its linkages stored in the discussion database will be retrieved and translated into a hierarchical concept map. The regenerated concept map will be stored in a relational database such as Microsoft Access for further use secondly. After the hierarchical concept map is translated completely, it would be able to replay in a 2-dimensional plane as a tree-like concept map as the top-right three blocks in the Figure 3 shown.

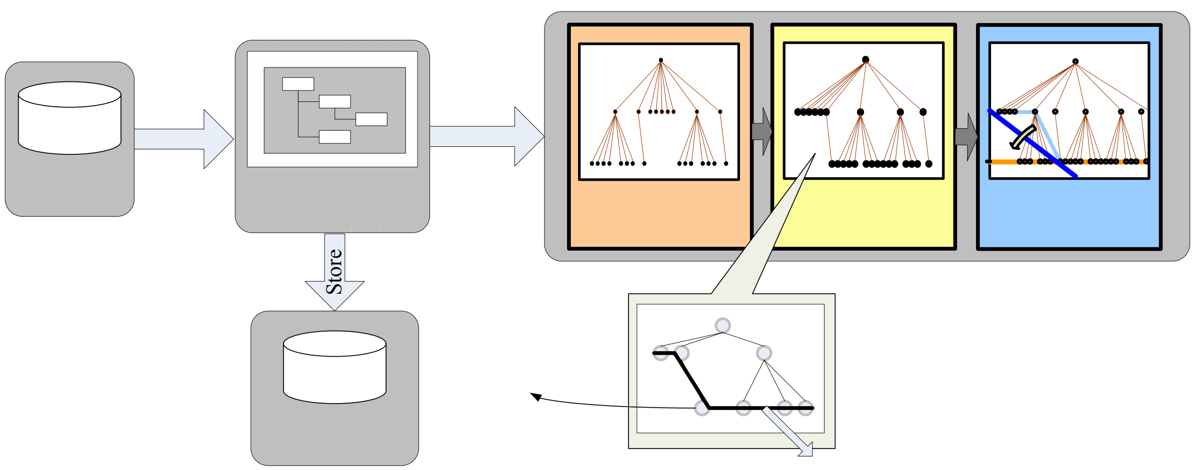

Figure 3. Tree-like Concept Map Generation, Map Replaying and Bending

The concept map presents the concepts in students' minds in which each concept has different depth as the tree-like concept map replay in the 2-dimension plane. There are different depths of concepts since students have different views to the same concept. If students had thought more specific, the depth (level) of the concepts will be much deeper. However, the hierarchical concept map is still complex for teacher to understand. Therefore, the hierarchical concept map is played as a tree-like concept map when we design the mechanism for measuring the consistency and similarity of concept maps between students and teacher.

The level of concepts in the tree-like concept map will be concerned by teacher because the level of concepts might have great meaning in the teaching process. If the tree-like concept map could be bended, the relations between students' map and teacher's map may be easier to find out. In this paper we bend the tree-like concept map according to the level of leaf nodes. The deeper a leaf node is we bend its branch to much closer to the right side (according to the x-axis) as the middle block (with a mark titled as "2-Dimension Plane Bending") of the top-right three tree-like concept maps illustrated in Figure 3. After bending, the tree-like concept map will be much easier to understand.

In order to provide the lacks of concepts for teacher, the comparison between the students' concept map and the teacher's concept map should be done. The supplement concepts then could be generated after integrating both of students' and teacher's tree-like concept maps with the *concept baseline*. As the right block (with a mark titled as "Integrated Concept Map") of the top-right three tree-like concept maps illustrated in Figure 3 shown above, two concept baselines and one *Adjustable Baseline* can be created. The leaf nodes in the tree-like concept map are the *base concept nodes* (shown in the right-bottom of Figure 3) which will spread at different levels and the line goes through every leaf nodes is so-called the concept baseline, which performs the base concepts in the human mind. Therefore, once we integrate the concept maps of students and teacher, there are two concept baselines in the intergraded concept map (as Figure 4 shown below).

After integrating the two tree-like concept maps, the Adjustable Baseline (crimson dash-dot line) will be created in the area between the concept baselines of students (gray dot line) and teacher (black line) in Figure 4. The Adjustable Baseline extends from the cross point between the concept baseline of students and teacher to left end-point of the students' concept baseline. Teacher can manipulate the Adjustable Baseline with counterclockwise direction, and those concepts touched by Adjustable Baseline are the lacks of concepts which might the students need as shown in Figure 4.

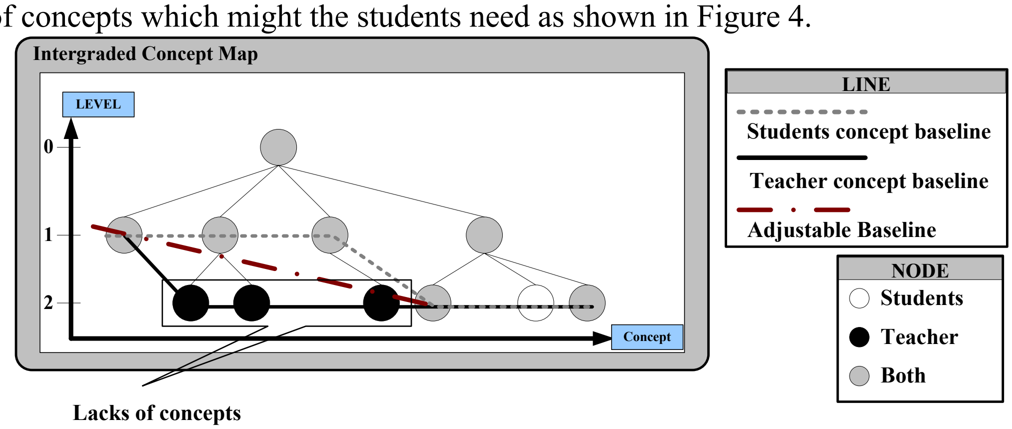

Figure 4. Intergraded Concept Map

There are three conditions which a concept might be in the Intergraded Concept Map:

1. teacher has the concept in his/her tree-like concept map only;
2. students have the concept in their tree-like concept map only;
3. both of teacher and students have the same concept in their tree-like concept maps.

Teacher will be easily to find these three conditions in the Intergraded Concept Map with different colors of concept nodes, in condition 1 the concept nodes will be in black; in condition 2 the concept nodes will be in white; and in condition 3 the concept will be in gray. Teacher will get the lacks of concepts from students easily, and provide the necessary supplemental materials to students according to the lacks of concepts.

4. Algorithms of the Mechanism for Measuring Consistency and Similarity

In this Section, there are three algorithms will be introduced one by one with the process order shown in Figure 5 below:

Algorithm 1: to replay the tree-like concept map from the concept map RDBMS;

Algorithm 2: to bend the tree-like concept map according to the depth of branches;

Algorithm 3: to generate the Intergraded Concept Map based on two tree-like concept maps.

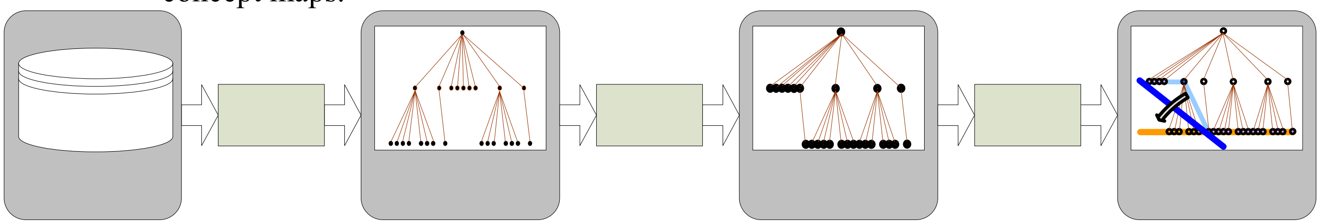

Figure 5. Algorithm flow chart

At first, the records stored in the concept map RDBMS can be used in replaying the tree-like concept map with Algorithm 1 as following. Secondly, the Algorithm 2 will bend the tree-like concept map based on the depths of each branches. At last, two tree-like concept maps of students and teacher could be feed into Algorithm 3, and an Intergraded Concept Map and its three related baselines (students' baseline, teacher's baseline, and the Adjustable baseline) will then be constructed and created.

Algorithm 1: Concept Map RDBMS → tree-based Concept Map
• Input: the students' concepts stored in concept map RDBMS • Output: tree-base concept map presented in 2-dimention plane 1.Set the weight of all nodes = 0 2. for leaf level to root level □Read the data of concepts which includes concept name and concept level from Concept Map RDBMS. □Get the parent-node of the concept. □Reset the weight = 1 + the maximum value of the concepts which belong to the same parent node (the illustration as shown in Figure 6) 3. Set the horizontal position of node by travel the tree by pre-order and the vertical position of node by the node level. 5. Link the lines with the parent-child relation.

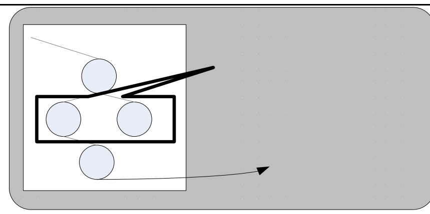

Figure 6. the illustrate of weight counting

Algorithm 2: tree-based Concept Map → Bending Concept Map
• Input: tree-base concept map presented in 2-dimention plane • Output: students' bending concept map 1. for (root level+1) to leaf level □bending the Concept Map in order the value of node weight, the bigger the node is, the more the node will be close to right side in the Concept Map. (the illustration as shown in Figure 7) 2. Set the horizontal position of node by travel the tree by pre-order and the vertical position of node by the node level. 3. Link the lines with the parent-child relation.

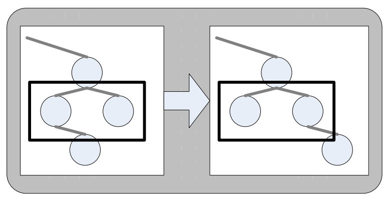

Figure 7. the illustrate of map bending

Algorithm 3: Bending Concept Map → Intergraded Concept Map
• Input: students' concept map & teacher's concept map • Output: The concept map intergraded with the concept map of students' and teacher's for root level to leaf level □Read teacher's concept data of which includes concept name and its parent node from Concept Map RDBMS. □if (teacher's concept is match to students' concept) Set node = match (color is gray) □else □teacher has the concept in the map only→set color of node is black and add the node in students' concept map □students have the concept in the map only→set color of node is black

5. Feedback System and its Outcome

According to the mechanism and algorithms proposed in this paper, the experiment feedback system is a Java-based application and running at the Information Program of the Chih-Ping Vocational School with the PBL teaching strategy. There are around fifty participants who are the first year students (most of them are male and divided into 8 small groups) of the vocational school in this experiment. The experiment lecture is **Dream Computer** and we select the 6^{th} team as example to explain the whole analyze and feedback process. The content of discussion is recorded and translated into the concept map (shown in Figure 8). After translating into the concept map from the discussion database, the tree-like concept map of the 6th team was bending in Figure 9 as shown below.

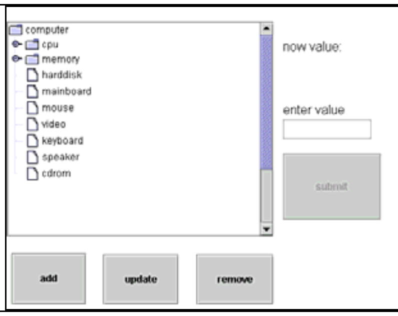

Figure 8. Concept Map generation

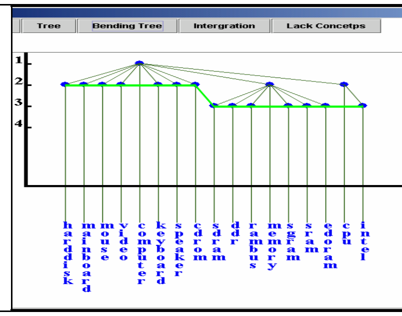

Figure 9. Bending Tree-like Concept Map and the Concept Baseline of 6th Team

After integrating, the Intergraded Concept Map will be generated and the Adjustable Baseline was created in Figure 10 below. The lacks of concepts will be listed on the right side of the feedback system by manipulating the Adjustable Baseline. Teacher can adjust his/her teaching strategies and provide supplemental materials according to the suggestions from the feedback system.

6. Conclusions

This paper proposes a mechanism to teachers for measuring the consistency and similarity of concept maps between students and teacher. With the tree-like concept map and the Adjustable baseline teacher will be able to know what the concepts are missing in students' mind, and teacher could provide the supplemental materials correspondently for students whom might need. It is comfortable for teacher to get the lacks of concepts from students easily with the mechanism. However, according to the teachers' suggestions, the feedback system that developed for the experiment lectures based on the PBL theory will be much better if it can provide instant (or say real-time) feedback. Currently, the feedback is provided to teachers only when the discussion stage (in PBL theory) is over. However, the discussion stage could be taken for more than one class and even let students do the discussion via Internet after school. Fortunately, the suggestion is easy to accomplish since we can simply let the feedback system activate anytime during the discussion stage.

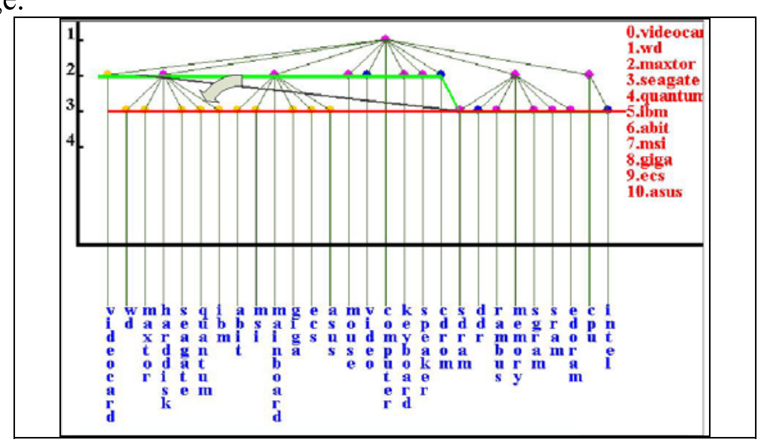

Figure 10. Integrated Concept Map & Lacks of Concepts

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