Available online at www.sciencedirect.com
ScienceDirect
Expert Systems with Applications 36 (2009) 1675–1684
Expert Systems with Applications
www.elsevier.com/locate/eswa

Application of automatically constructed concept map of learning to conceptual diagnosis of e-learning

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Abstract

The concept map proposed by Novak is a good tool to portray knowledge structure and to diagnose students' misconception in education. However, most of the learning concept maps have to be constructed through the suggestions of experts or scholars in related realm. It is really a complicated and time-consuming knowledge acquisition process.

The study proposed to apply the algorithm of Apriori for Concept Map to develop an intelligent concept diagnostic system (ICDS). It provides teachers with constructed concept maps of learners rapidly, and enables teachers to diagnose the learning barriers and misconception of learners instantly. The best Remedial-Instruction Path (RIP) can be reached through the algorithm of RIP suggested in this study. Furthermore, RIP can be designed to provide remedial learning to learners. Moreover, by using statistical method, the study analyzed 245 students' data to investigate whether the learning performance of learners can be significantly enhanced after they have been guided by the RIP.

Keywords: E-learning; Concept map; Portfolio; Data mining; Test question association rules

1. Introduction

With the popularization of information technology and computer network, the location of instruction activity has been varied from the traditional classrooms to the internet, forming the so-called e-learning. However, lacking physical teaching activity and guidance in the e-learning environment, by what means the teachers can evaluate the learning barriers, misconception and learning performance of students in the portfolio of learners would be an important research issue of today.

Nevertheless, many scholars think that online evaluation is an important learning response index for the instruction process. But most of the online evaluation system can only show the total scores, answers, solution analysis and position of the testees, they cannot help teachers to understand the students' degree of familiarity with the knowledge from the test portfolio of testees.

Therefore, the study proposed using the algorithm of Apriori for Concept Map to develop the ICDS of an automatically constructed concept map of learning. The practice was to use the test question association rules of data mining to analyze the test portfolio of learners, and to adapt the automatically constructed concept map of learner to produce the diagnostic analysis reports. It not only shows the learning performance of students, but also provides useful clues to the learning barriers of students. Learners are able to know immediately which of their concepts should be further remedied, thus achieving the objectives of remedial learning.

The construction of concept map of learning can be generally divided into three kinds: completely manual, semi-automatic and automatic construction (Tseng, Tsai, Su, Tseng, & Wang, 2005). Among these three kinds, the completely manual construction is a constructive way through the suggestions of educational or field experts and scholars. It is really a complicated and time-consuming knowledge acquisition process.

In view of the above situations, the study was made with the following purposes:

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doi:10.1016/j.eswa.2007.11.049

(1) To actually develop the ICDS of an automatically constructed concept map of learning by the algorithm of Apriori for Concept Map combined with the testee's test portfolio.
(2) Teachers were provided with the rapidly constructed concept map of learners to diagnose the learning barriers and misconception of learners.
(3) Through the analyzes of the concepts and weight in the concept map, RIP was constructed to offer remedial learning.
(4) Statistical methods were used to analyze whether the learning performance of learners can be significantly enhanced after they have been guided by the RIP.

2. Literature review

In a learning activity, each step has a learning focus, which was called "concept". The learning of these concepts should be done in a proper sequence. We call this kind of learning sequence as epistemological order (Chen & Hsia, 1999). For example, the learning of "multiplication" must be preceded by the learning of the concept of "addition". "Epistemological order" is used to standardize the learning order of different concepts. Let us present the epistemological order in Fig. 1. In the figure, A and B represent two concepts. The connecting line between A and B represents that there is a correlation of a certain epistemological order in between. The arrow of the connected line represents the learning order. Therefore, Fig. 1 indicates that Concept A precedes Concept B in terms of the epistemological order.

Through a series of combination of the epistemological order, a topological graph can be acquired, and is called "conceptual graph" (Novak, Gowin, & Johansen, 1983; Plotnick, 1997). Conceptual graph is proposed by Professor Novak of Cornell University of the United States to express the hierarchal structure of knowledge (Novak & Gowin, 1984).

Since "conceptual graph" can make the relationships between concepts more organized and systematic and present the learning order of concepts, the paper intended to use these properties of conceptual graph to find out the misconception of students in the learning process. For example, regarding the epistemological order shown in Fig. 2, learners should learn Concept A first, and then Concept B and Concept C. Therefore, if a learner is found to have a learning barrier during the learning of Concept B, we can presume that the learner's learning difficulty of Concept B is caused by his/her incomplete learning of Concept A. Therefore, Concept A may be the misconception of the learner.

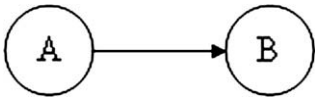

Fig. 1. Epistemological order of concept map.

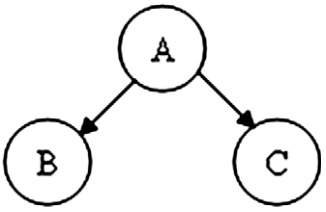

Fig. 2. Relationships of the epistemological order.

When a certain learner is judged to have a misconception of Concept C, the father concept that has the closest relation with the misconception of Concept C can be acquired. After repeated searching, a path that takes Concept C as the starting point and goes through a series of concepts is obtained. The concepts that the path passes through are judged by the system as the related concepts that may probably be the causes of the unsatisfactory performance in learning Concept C. This path is called the Remedial-Instruction Path (RIP) (Chung, Lin, & Wu, 2001).

Concept map is a combination of many important learning theories. In fact there are hundreds of researches papers relate to the application of concept map in education, but they hardly touch upon the application of concept map to e-learning. Therefore, concept map still has a rather great room for research in the realm of e-learning, and is worthy of making in-depth investigation.

3. Research approach

The study proposed the algorithm of Apriori for Concept Map which includes the following eight procedures that the concept map of learning has to complete.

3.1. Presetting conceptual weight of test question by teachers

In the realm of science curricula, a test question may not correspond to one concept only. A test question may at the same time include two or more than two concepts. Therefore, when a teacher presets the relevance of concepts to questions, the weight of concepts in each question has to be predetermined by the teacher. If a test question contains a single concept, the relevance degree will be represented by "1". If a test question contains two or more than two concepts, the conceptual weight (0–1) distributed to different test questions will be presented by the degrees of strong, medium and weak. If a test question does not contain any concept, it will be represented by "0", and the total weight of the test question is 1, as shown in the comparison chart of conceptual weight relationships in test questions in Table 1. Five test questions (Q1–Q5) cover five concepts (C1–C5) which are designed for the curriculum.

3.2. Recording the test portfolio of each testee

Suppose there is a table of test portfolio with 5 testees having given wrong answers in the test of a subject, as