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Developing Virtual Tutors for online PBL Discussion Board Using Concept Map Scoring

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Abstract: With the development of the information technology, digital learning is introduced to construct problem-based learning systems, such as online discussion. This paper investigated on-line PBL processes and designed intelligent tutors with pragmatics and semantic concept map. The tutors interact with students based on the observed concept map and provide guidelines for students' on-line discussion. A preliminary experiment is carried out to exam the system implementation. The result shows the effectiveness of the proposed method and the possibilities of sharing the burden of instructors for online discussion.

Keywords: Intelligent tutor, Problem-based learning, concept map, online discussion

1. Introduction

With the rapid development of computer technology and Internet communication, the learner-centric learning style has become a new trend of pedagogical methodology. (Stephenson, Brown and Griffin, 2008) Problem-Based Learning is one of the popular learner-centric learning styles. PBL is defined as a learning that results from the process of working towards the understanding of a resolution of a problem. (Barrows and Tamblyn, 1980) Operationally, students encounter a problem, then form a PBL group to discuss the problem and brainstorm ideas, accordingly they go studying the learning issues independently and come back to share information, and finally the learning results are presented and reviewed. (Yang and Chang, 2005)

Recently, Internet advanced technologies are widely introduced to construct PBL tools and systems, such as POLARIS (Problem-Oriented Learning and RetrIeval System) (Lutgens, Koehorst and Ronteltap, 2004), CoMMIT (Collaborative Multi-Media Instructional Toolkit) (Lautenbacher, Campbell, Sorrows, and Mahling 1997), PsyWeb (Koehorst, Ronteltap, Schmidt, and Winke, 2002), and eSTEP (e-Secondary Teacher Education Project). (Derry, 2006)

Throughout the PBL process, group discussion plays the crucial role of the successful learning. In E-PBL, online discussion board provides the environment of group brainstorming and forming the concept map. Therefore, the loading and responsibilities of the instructors in discussion board are significant. The goal of this research is to create virtual tutors to ease the burden of the online instructors. By analyzing the concept map forming in the discussion board, the virtual tutors are able to promote the learning topics, guide the discussion, motivate and remind the fall-behind students.

2. Research Background

2.1 Concept Map

In PBL learning, concept map is commonly used to evaluate or reveal the understanding of the assigned problem and solution. Concept map is one kind of visual knowledge representation, which can be used to express students' understanding about topics. (Novak and Gowin, 1984; Novak, 1998; Canas, et al., 2005; Novak and Canas, 2008). Teachers can evaluate students' concept map to judge the comprehension level of students. (Gouli, Gogoulou, Papanikolaou, Grigoriadou, 2005)

A concept map includes concepts and the in-between relationships. (Novak and Canas, 2008) As Figure 1 shown, the concepts in a concept map are denoted as nodes, which express in single words or short phrases, and the in-between relationships are described as directed edges with labels, called propositions. (Turns, Atman, Adams, 2000) Normally, one labeled relationship will connect two concepts; for example, the proposition connecting “concept maps” and “organized knowledge” can be interpreted as “concept maps represent organized knowledge.”

2.2 Concept Map Scoring

Using the concept map to assess students’ outcome led to the concern of the reliability and validity of concept map scoring (Klein, Chung, Osmundson & Herl, 2002). Many scoring scheme have been discussed and proven the reliability and validity of accessing students concept maps during the learning process. Other than the holistic examination, concept map scoring methods fall into two main categories, structural schema and relational schema. Both of them maintain their advantages and disadvantages due to the properties of learning content. In this research, we adapts the relational schema for concept map scoring due to the simplicity and robustness.

The reliability and validity of the relational scoring method has been verified in (McClure & Bell, 1990; McClure, Sonak & Suen, 1999). The main idea of the relational scoring schema is to evaluate the concept map as a combination of propositions which is two concepts connected with a relation. Each proposition can be scored from 0 to 3 depends on the user definition. The summed-up score of the concept map represents the similarity of the master concept map.

There are three main criteria in the relational scoring method:

1. Links between compared concepts in master map
2. Label of relationship indicates a possible relationship
3. Direction of arrow indicates a hierarchical relationship

In this research, the first criterion of the relational scoring method is applied to score the discussion concept map comparing to the master concept map. A concept map could be decomposed into a set of propositions. Therefore, master map and student map are decomposed into two different set of propositions: M and S. If any proposition p in student map S and proposition p can be found in master map M, then student map S get 1 point.

2.3 Pragmatics

In linguistics, the study of the relations of a sign (word) to other signs (words) in a language is called syntactics; whereas, semantics investigates the relations of a word to objects that it signifies (means). Quite different from syntactics and semantics, pragmatics focuses on the relations of linguistics word to their users or its interpretants. Formally, Austin began the research of pragmatics, especially SAT (Speech Act Theory).(Austin, 1962) It naturally matches the interactive acts among students in the online discussion boards. Based on the pragmatics, the discussion thus can be segmented and then extracted the corresponding concepts.

Speech act theory classifies the acts of a speech into three parts: (1) locutionary act, related to the meaning of its contents; (2) illocutionary act, indicating the act performed by the speech action; and (3) perlocutionary act, meaning the consequence of the speech. Additionally, the illocutionary acts are analyzed into verdictives (e.g., estimate, assess), exercitives (e.g., warn, order), commisives (e.g., promise, undertake), behavitives (e.g., apologize, commend), and expositives (e.g., conclude, assume), (Austin, 1962) or representatives, directives, commisives, expressives, and dekclarations. (Searle, 1972)

3. Virtual Tutors Development

3.1 System model

Fig. 1 shows the proposed system model. The system first captures raw discussion sentences during students’ discussion periodically. The system logs all the users’ behaviors in the database including time, discussion content, logging behavior, etc. Virtual tutors can obtain necessary data through accessing database. To segment the discussion, pragmatics indexing is applied. Sentence segmentation is a collection of collection of sentences in same *turn* and input is a set of sentences which are already indexed as REQUEST, POSTIVE_EVALUATE, CHAT or REPLY. Sentence indexed in REQUEST is considered as an open of a new turn and end of previous turn.

Segmented sentences can be treated as sentences in the same theme. Once the concepts in the discussion group have been spotted, the relationships among concepts then can be constructed. In pragmatic, concept relationship mostly occurs in the same turn, in other words, these sentences appear in same turn, should describe same theme. Hence, concepts extracted from sentences which appear in same turn should be described same theme. Therefore, concept map could be built using the concept miner. Sentences then are converted to parse tree by Sinica treebank. The tutors can discover concepts through parse trees of discussion sentences.

Once the students' concept map is built, the tutors compare the map against the master map which is defined by teacher and score the map. Based on the score, the tutors thus can evaluate the performance and provide the feedbacks. The detail mechanism of feedback is discussed in the later section.

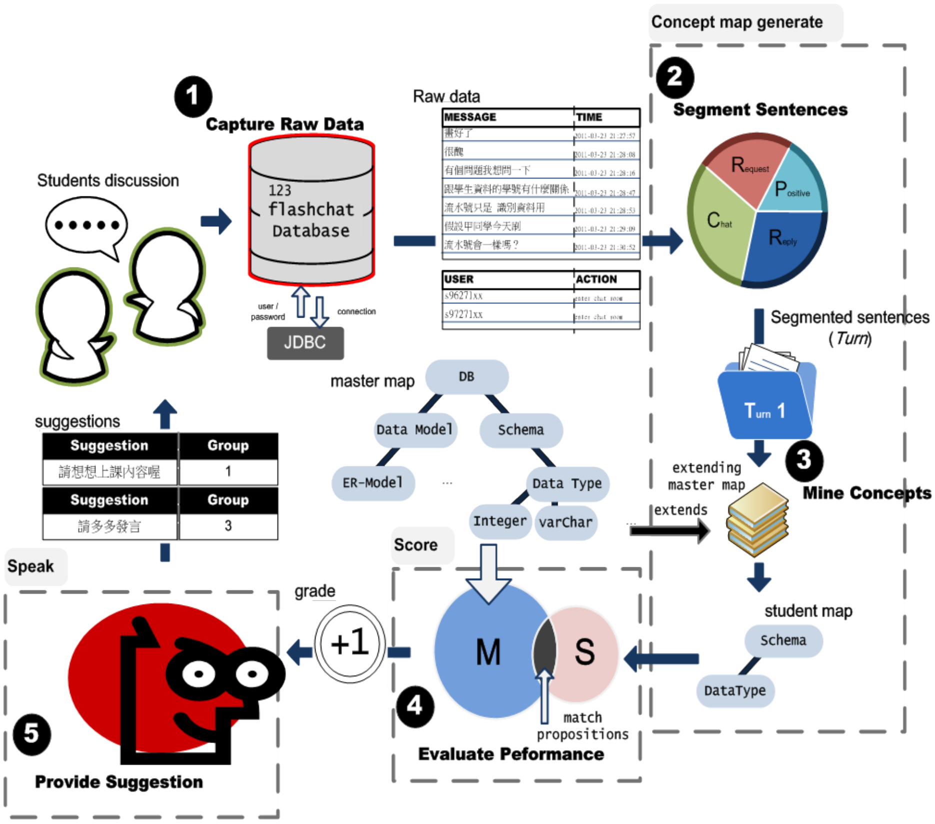

Figure 1. System Model

3.2 Tutoring feedback

To give appropriate feedbacks, several factors are concerned in E-PBL discussion board:

A. Understanding of the discussion content

In this research, we adapt automatic concept map construction from students' discussion contents to achieve this objective. The intelligent virtual tutors can evaluate concept map of students to know students' comprehension about discussion topics and provide suggestions based on evaluation results.

B. Learning motivation

Because of negative feedbacks would cause the diminish of motivation, the research avoids negative suggestions during the discussion such as「You guys are wrong」. Instead, virtual tutors would encourage student with positive or neutral suggestions such as 「Please think of related topics」. We expect that positive or neutral suggestions could encourage and motivate students to discuss more about the topics.

C. Reminder

The common problem in online discussion is the control of speak due to not face-to-face interaction. Instructor as a kindly reminder is necessary and helpful for promoting students to discuss the given topic. Maintaining the discussion board in high frequent interactions would also increase the intention of students' participation.

Based on the above concerns, the system designs the feedbacks of the virtual tutors including:

Participation promoting

The virtual tutors will evaluate the participation of students and encourage low-participated students to be more 'active' in the discussion.

The participation could be formulated as:

$$amount(sentence_s)/timeperiod\ . \tag{1}$$

where $amount(sentence_s)$ is the amount of sentences student s speaking, and $timeperiod$ is a unit of time such as 60 seconds or 120 seconds. For example, if the sentence amount of student s in 60 seconds is 10 then the participation of student s is $10/60 \approx 0.167$.

Learning achievement encouraging

In the system, tutors monitor the construction of students' concept map periodically. The learning achievement is evaluated by the concept map scoring scheme from time to time as shown below.

$$\begin{aligned} &\textit{learning achievement increasing } i_{t+1\sim t} \\ &\quad = Scoring(M, S_{t+1}) - Scoring(M, S_t) \end{aligned} \tag{2}$$

Tutors will give appropriate suggestions based on the observed student progress. When the concept map score is below the threshold, the virtual tutors will promote students to discuss more and remind them the learning topics. In the other hand, if the group discussion is effective and the concept map score is above threshold, tutors would like to keep the discussion going.

3.3 System Implementation

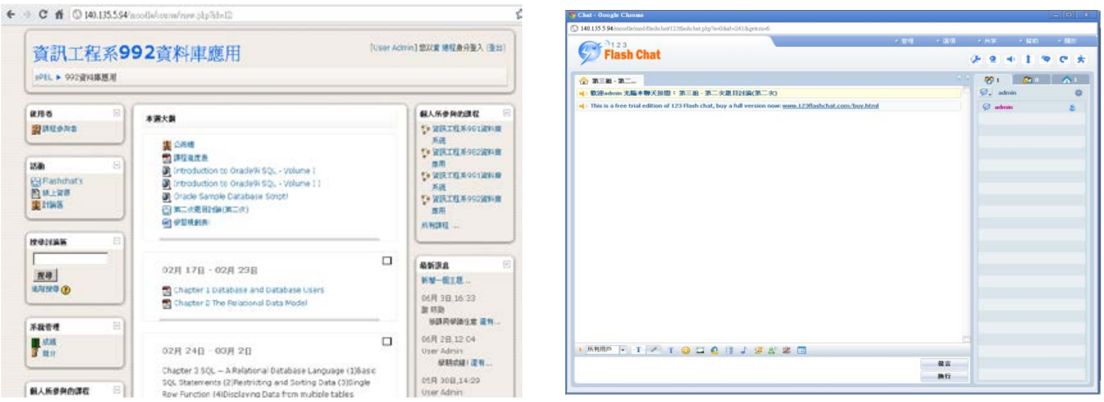

Figure 2. System Implementation

Fig. 2 shows the system implementation. The system is built on Moodle platform. The online discussion board is implemented on 123flashcat which is served as an activity by Moodle. students can start their own discussion through the provided Moodle interfaces. Also, other learning activities can be carried out such as obtaining learning materials and exercises on Moodle as well.

All the activities in the discussion board will be recorded in the databases. Consequently, virtual tutors analyze discussion contents, score the concept map and give the sound feedbacks to encourage learning. In general, 123flashchat could support multiple discussion boards at the same time. For tutors' performance, we limit one group discussion at one time and schedule other groups in different time slots to get the better interaction.

4. Experiments

We apply the system to a college-level database management system course under e-PBL environment. Tutors play roles of discussion assistants who would remind students to be more 'active' and request students to utilize course content to solve given problems. During the course, the instructor first lectures brief knowledge about database. 34 students in the class are divided into six small groups, and each group has five to six students. Students are allowed to form their own group freely. Each group is assigned to discuss same topics in E-PBL. In this experiment, the master concept map for the selected topic is constructed with 35 concepts and 34 links by the instructor. The discussions are carried out without the presence of the instructor. During the discussion, the system records the assessment information for each group including the number of extracted concepts, the number of link, score, time and the number of sentences After each discussion is over, students present their solutions about the assigned questions in oral presenting and accomplish self assessment, peer assessment. In addition, we use TAM (Technology Acceptance Model) questionnaire to learn acceptance of our system.

Table 1. Statistic results for online discussion

Group	Concept	Link	Time	Mean	Participation	CV
A	11	4	405.0144	131	High	33.81257
B	7	1	119.5107	108.5	Low	78.7987
C	7	1	271.7443	113.75	Low	28.18105

The results show the assessment of the small group discussion based on the two aspects mentioned in the previous section: degree of participation, and learning achievement. The time and the number of sentence simple can be used to evaluate degree of participation and interaction. However, as to the cognitive and content-related posts, the constructed concept map and the score well represent the level of understanding for each assigned topic. According to the results, group A shows not only high participation and interaction but also high score on concept map scoring.

The following sample questions are the test of the usefulness and ease of use for the virtual tutors in TAM model.
Usefulness:
Q1: The virtual tutors can speed up the progress of the discussion
Q2: The virtual tutors can enhance the understanding of the learning content
Q3: The virtual tutors can improve the learning outcome
Q4: The virtual tutors overall can help my discussion
Ease of use:
Q5: The design and presentation of the virtual tutors are easy to understand
Q6: The suggestions from tutors are reasonable and understandable
Q7: The use of tutor is intuitive

Table 2. Statistic results for usefulness and ease of use for the virtual tutors in TAM model

	Strong agree	Agree	Neutral	Disagree	Strong Disagree
Q1	4.17	50.00%	41.67%	4.17%	0.00%
Q2	0.00	62.50%	29.17%	8.33%	0.00%
Q3	0.00	54.17%	33.33%	12.50%	0.00%
Q4	0.00	50.00%	41.67%	8.33%	0.00%
Q5	8.33	62.50%	25.00%	4.17%	0.00%
Q6	0.00	45.83%	41.67%	12.50%	0.00%
Q7	8.33	45.83%	37.50%	8.33%	0.00%

In Table 2, over 50% students agree virtual tutors can improve discussion progress, over 60% students agree virtual tutors can help students to familiarize course content, over 50% students agree virtual tutors can improve the discussion result and over 50% students agree that virtual tutors overall can help the online discuss. Therefore, the results reveal the correspondences with the performances of the group discussions.

5. Conclusions

This research proposed virtual tutors which can increase learning motivation and promote learning activity. To access students' comprehension, we try to construct and evaluate students' concept map during the discussion. The process of the knowledge construction could be observed through the proposed method. In addition, the virtual tutors can play the roles of discussion instructors that ease the burden of instructors who adapt E-PBL as the curriculum plan.

The extending master map is adapted to mine concepts from discussion contents. Using the extending master map, some concepts defined in master can be found. However, some misspell words cannot be recognized. The extending master map should be able to expand or tolerate such mistakes. Second, effectiveness of suggestion should be acknowledged. Observation shows that some suggestions are not effective for some students. In the future, some mechanisms can be applied to detect the effectiveness of the suggestion and be able to adjust and react based on the instant feedback.

References

Austin, J. L. (1962). How to Do Things with Words. Oxford Univ. Press. Oxford.

Barrows, H. S. Barrows and Tamblyn, R. M. (1980). Problem-Based Learning—An Approach to Medical Education, Springer, 1980

Cañas, J., Carff, R., Hill, G., Carvalho, M., Arguedas, M., Eskridge, T. C., Lott, J., and Carvajal R. (2005). "Concept Maps: Integrating Knowledge and Information Visualization", Knowledge and Information Visualization, Lecture Notes in Computer Science (LNCS), 3426, pp 205-219.

Derry, S. J. (2006). eSTEP as a case of theory-b;ased web course design. In A. M. O'Donnell, C. E. Hmelo-Silver & G. Erkens (Eds.), Collaborative reasoning, learning and technology, pp.171-196.

Gouli, E., Gogoulou, A., Papanikolaou, K., and Grigoriadou, M. (2005). "Evaluating Learner's Knowledge Level on Concept Mapping Tasks", Proceedings of the Fifth IEEE International Conference on Advanced Learning Technologies (ICALT'05), pp 424 – 428.

Klein, D.C.D., Chung, G.K.W.K., Osmundson, E., Herl, H.E.(2002) Examining the Validity of Knowledge Mapping as a Measure of Elementary Students' Scientific Understanding. CSE Report 557, University of California, Los Angeles, 45p.

Koehorst, A., Ronteltap, F., Schmidt, H.G., and Winkel, W. W. R. (2002) Design, Implementation and Evaluation of PsyWeb, a Learning Environment in a Problem Based Learning Curriculum. The New Educational Benefits of ICT in Higher Education: Proceedings, pp 119-124.

Lautenbacher, G. E., Campbell, J. D., Sorrows, B. B. and Mahling, D. E. (1997). Supporting collaborative, problem-based learning through information system technology. Proceedings on Frontiers in Education, pp.1252-1256.

Lutgens, G. , Koehorst, A. and Ronteltap, F. (2004). POLARIS: a Building Block for Blackboard to Support Collaborative Learning, Networked Learning Conference

McClure, J.R., & Bell, P.E. (1990). "Effects of an Environmental Education-Related STS Approach Instruction on Cognitive Structures of Preservice Science Teachers.", University Park, PA: Pennsylvania State University. (ERIC Document Reproduction Services No.ED 341 582)

McClure, J. R., Sonak, B., and Suen, H. K. (1999), "Concept Map Assessment of Classroom Learning: Reliability, Validity, and Logistical Practicality", Journal of Research in Science Teaching (JRST), 36(4), pp 475-492

Novak, J. D. (1998). Learning, Creating, and Using Knowledge: Concept Maps As Facilitative Tools in Schools and Corporations, N.J. Mahwah, Lawrence Erlbaum & Assoc.

Novak, J. D. and Cañas, A. J. (2008). The Theory Underlying Concept Maps and How to Construct and Use Them, Technical Report IHMC CmapTools 2006-01 Rev 01-2008, Florida Institute for Human and Machine Cognit;ion,.

Novak, J.D. & Gowin, D.B. (1984). Learning How to Learn, Cambridge, Cambridge University Press

Stephenson, J., Brown, C., and Griffin, D. (2008) Electronic delivery of lectures in the university environment: An empirical comparison of three delivery styles. Computational & Educational, 50 (3), 640-651.

Searle, J. R. (1972) What is a speech act? in Giglioli, P. (ed.) Language and Social Context. Harmondsworth: Penguin.

Turns, J., Atman, C. J., Adams, R. (2000). "Concept maps for engineering education: a cognitively motivated tool supporting varied assessment functions", IEEE Transactions on Education, 43(2). pp. 164 - 173

Yang, K.-Y. and Chang, L.-M.-L. (2005). The Theoretical Foundation and Learning Process of Problem Based Learning. Chung Yuan Journal, 33(2), 215-235