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An innovative concept map approach for improving students' learning performance with an instant feedback mechanism

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Abstract

Concept maps have been widely employed for helping students organise their knowledge as well as evaluating their knowledge structures in a wide range of subject matters. Although researchers have recognised concept maps as being an important educational tool, past experiences have also revealed the difficulty of evaluating the correctness of a concept map. It usually takes days or weeks for teachers to manually evaluate the concept maps developed by students; consequently, the students cannot receive timely feedback from the teachers, which not only affects their learning schedules, but also significantly influences the students' learning achievements. In this paper, a computer-based concept map-oriented learning strategy with real-time assessment and feedback is proposed in order to cope with the problems mentioned above. Our approach provides immediate evaluation of concept maps and gives also real-time feedback to the students. An experiment has been conducted to evaluate the effectiveness of this new strategy in comparison with the conventional computer-based concept map approach. It is found that our innovative approach can be significantly beneficial to promote learning achievements as well as the learning attitudes of students.

Introduction

Novak and Gowin (1984) pointed out that instructors should teach new knowledge based on learners' original cognitive structures, so that they can connect old cognitive structures with new ones to form meaningful learning. During the past 10 years, concept maps have been used as a tool for supporting meaningful learning in science teaching and for helping students and experts to represent and visualise their knowledge structures (Novak, 2002). Through concept maps, learners are able to externalise their original knowledge and combine it with new one for re-arranging and internalising both the old and new knowledge (Erdogan, 2009; Lim, Lee & Grabowski, 2009; Trundle & Bell, 2010). Akinsanya and Williams (2004) stated that concept maps are effective tools for students to clarify their knowledge structures; consequently, they have encouraged educators to take concept maps into consideration when designing their course plans.

Owing to the popularity of computer technology, the use of computerised concept maps has become popular. Several previous studies have shown that the students who learned with computerised concept map systems had better learning achievements than those who learned with traditional approaches (Kim & Olaciregui, 2008). The advantages of computerised concept maps include the ease of making corrections, the flexibility of presenting content and the availability of promoting interactions among teachers and students (Liu, Chen & Chang, 2010; Reader & Hammond, 1994; Shin, Deno, Robinson & Marston, 2000). In the past decade, a number of studies have attempted to develop computer-assisted learning or assessment systems combined with the concept map strategy. For example, Hwang (2003) and Hwang, Tseng and Hwang (2008) employed concept maps to develop learning systems, which can diagnose students' learning problems and provide personalised learning guidance, as well as appropriate learning materials.

In the meantime, several studies have highlighted the importance of giving prompt feedback to students (Denton, Madden, Roberts & Rowe, 2008; Draper, 2009; Jordan & Mitchell, 2009; Li, Liu & Steckelberg, 2010). For example, Narciss and Huth (2006) claimed that immediate feedback is obviously beneficial for learning achievement and motivation. Moreover, Carroll's (1963) mastery theory also emphasised the advantages of providing immediate feedback. In a mastery theory-oriented learning activity, teachers give instructions based on the teaching goal, try every possible way to assist students in repeated practice and allow students to have enough practice in order to achieve the learning goal. An objective evaluation standard is needed for assessing the learning achievements of students and providing feedback to them based on the assessment results during the repeated practice process that enables students to learn continually until they reach a certain level of achievement (Chu, Hwang & Huang, 2010; Johnson, Perry & Shamir, 2010; Lalley & Gentile, 2009; Panjaburee, Hwang, Triampo & Shih, 2010). Consequently, it can be seen that the provision of instant feedback is very important to the students in enabling them to learn continually until reaching a certain level of achievement or organising their knowledge in a more meaningful way, in particular, for those complex learning tasks such as the development of concept maps.

Unfortunately, although learning with concept maps seems to be promising, researchers have pointed out a critical problem for using concept maps to support learning; ie, an extra load is created for the teachers who have to evaluate the maps developed by individual students. Usually it takes days or weeks for teachers to complete the evaluation of the concept maps; therefore, the students cannot receive feedback immediately (Ingeç, 2009). Denton *et al* (2008) indicated that instructors confront a number of challenges if they wish to return meaningful and instant feedback to individual students. Therefore, giving instant and meaningful feedback for complex learning tasks such as the development of concept maps has become an important and challenging issue (Denton *et al*, 2008; Hwang, Chu, Shih, Huang & Tsai, 2010).

To cope with this problem, this study proposes a computer-based concept map-oriented learning approach with real-time assessment and instant feedback. With the prompts and feedback, the students can reflect on and make modifications to their concept maps immediately; ie, they do not need to wait for the evaluation results from the teachers before proceeding with their learning process. Thus, the research questions that guided the work presented in this paper can be formulated as following:

1. Are the learning achievements of the students who learn with this proposed approach (concept map strategy with instant feedback) significantly higher than those who learn with the traditional concept map approach?
2. Are the learning attitudes of the students who learn with the new approach more positive than those who learn with the traditional concept map approach?

3. Are the technology-acceptance degrees of the students who learn with the new approach significantly higher than those who learn with the traditional concept map approach?

The paper is organised as follows: the next section describes our approach that combines concept maps with an instant feedback mechanism and the technology to support this process. The following section presents the experimental design including a detailed description of the participants, treatments and measuring tools. Analysis and discussions of the results introduced in the previous section are presented in order to get a better understanding of the different aspects and outcomes of the learning process. Finally, in the last section, concluding remarks are drawn and future steps are put forward.

A concept map approach with an instant feedback mechanism

In this study, a concept map approach with an instant feedback mechanism is proposed. Guided by this innovative perspective, a web-based learning system is developed for helping the students efficiently create and modify their concept maps based on the knowledge and experiences gained from the practice, such that their learning achievements can be improved.

System framework and functions

We have called the system that combines concept map-oriented learning with an instant feedback mechanism the 'Interactive Concept Map-oriented Learning System' (ICMLS). Figure 1 illustrates the different components of ICMLS, in which CmapTools, developed by the Institute for Human and Machine Cognition (IHMC) of the Florida University System (Novak & Cañas, 2006), is adopted as the concept map editing tool to work with the assessment and feedback system in the learning activities. CmapTools is a well-recognised tool for constructing, navigating and sharing knowledge models represented as concept maps. It enables learners to construct concept maps in personal computers and share them on servers via the Internet (http://cmap.ihmc.us/conceptmap.html).

The concept maps developed by the students are stored in a database. Via accessing the database, the students can revise their maps. When submitting a new version of a concept map, the

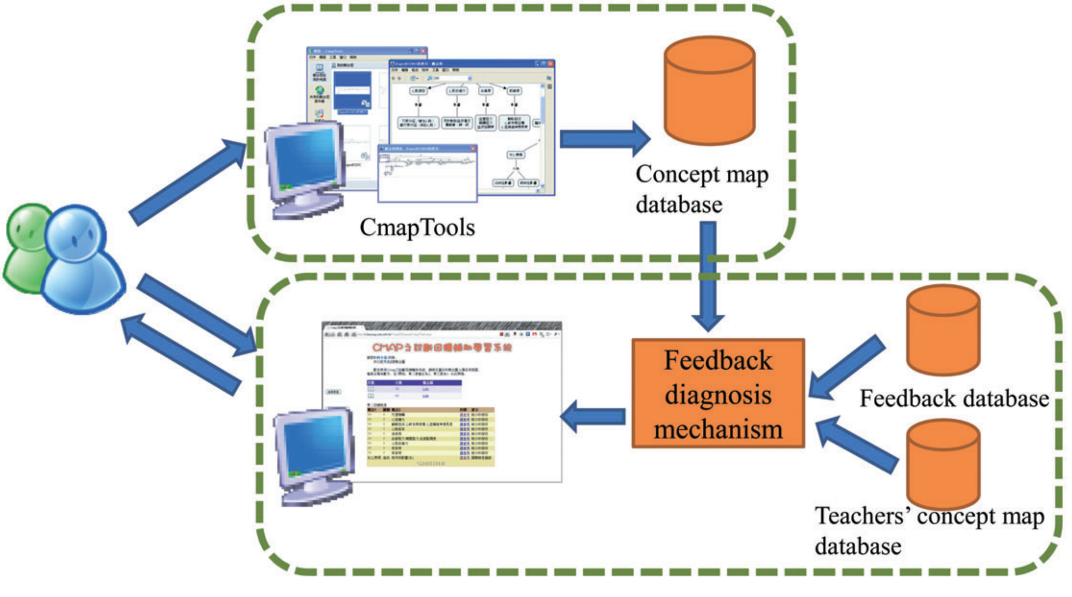

Figure 1: The different components of the computerised concept map system with an instant feedback mechanism

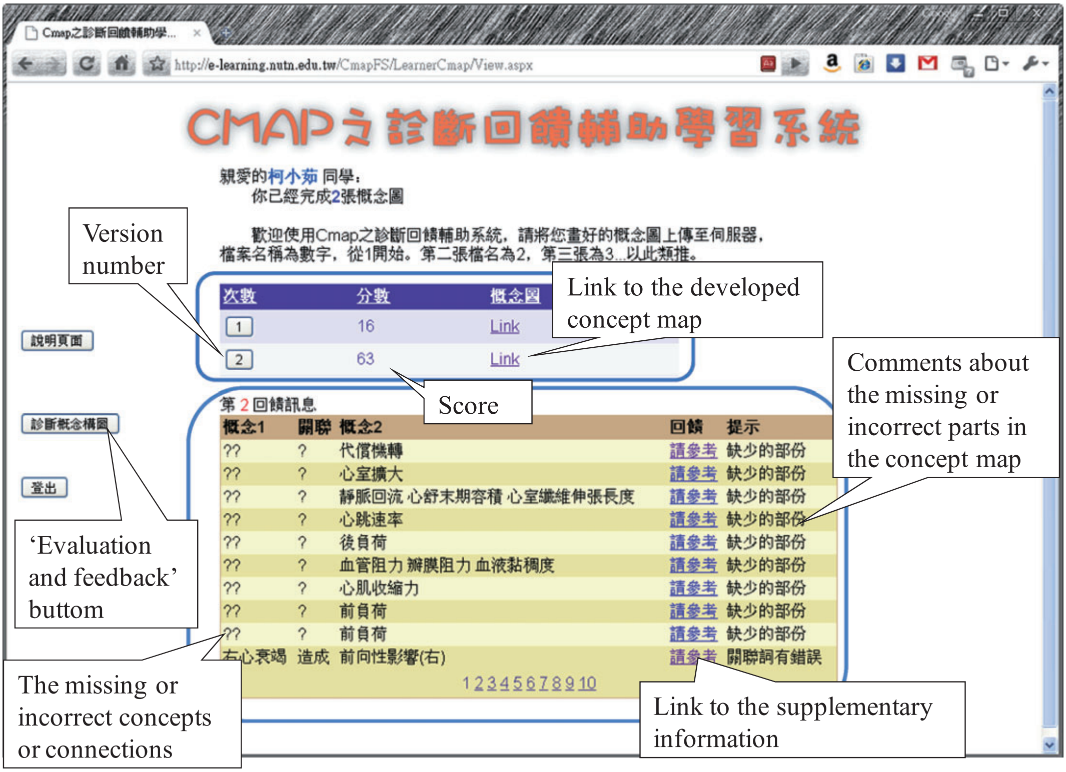

Figure 2: Interface of the instant feedback mechanism

students will receive feedback as well as supplementary materials from the assessment and feedback system, as shown in Figure 1.

To create or modify concept maps, students use a concept keyword list compiled by the teachers. With the acquired knowledge, the students employ CmapTools to concretely present the relevant knowledge with concept maps, which enables the students to deliberate on the connections among these concepts, and reorganise the links of each concept.

When the students finish drawing their concept maps, the maps will be retrieved automatically by the assessment and feedback system for evaluation. Based on the evaluation results, the system will provide feedback, supplementary information, as well as it will retrieve the concept map scores to the students. The feedback includes the score and a set of comments on the structure of the concept map developed by individual students, such as 'There is a missing notion related to Concept A' and 'There is a missing connection related to Concept A and some other Concept'. On the other hand, the supplementary information is a set of learning materials related to the missing or incorrect concepts/connections. When a student's concept map is closer to the target concept map developed by the teacher, the feedback contains fewer comments and a higher score; in the meantime, less corresponding supplementary information is provided.

Figure 2 shows the interface of the assessment and feedback system. The 'historic concept map area' shows the version number, scores and the link to each version of the concept map. By clicking on the links, the students can review their old concept maps on the Web, which enables them to compare their new versions with the old ones. The concept maps with higher scores indicate a higher degree of completeness and accuracy. Clicking the 'score' button in the historic concept map area will bring up the feedback to that version of the map, including the hints concerning the incorrect or missing concepts, the incorrect or missing connections between concepts and the supplementary materials about the concepts.

Figure 3 presents an example of using the instant feedback mechanism in a learning activity for a surgical nursing course. The student uses CmapTools to create concept maps for presenting the knowledge about ‘heart failure’. The pop-up window marked with ‘1’ in Figure 3 shows that, after completing the new (second) version of the concept map, the student presses the button ‘assessment and feedback’ to derive the score of the concept map (ie, 63). In the historic concept map area, the student can make comparisons between the first and second versions of the map, as shown in the pop-up window marked ‘2’.

Moreover, it is found that the student’s concept map has indicated that ‘right heart failure’ causes ‘forward influence’; however, the relationship between the two concepts should be ‘forward influence’ is one kind of ‘right heart failure’. Consequently, the system provides the student with a hint about the incorrect connection between the two concepts, as shown in the pop-up window marked ‘3’. The student can then make further modifications to the map and submit a new version to the learning system. It is expected that the students will submit more complete concept maps and derive higher scores after receiving the hints, browsing the supplementary information and reflecting on their previous concept maps, no matter whether the improvements are significant or not. In cases where students fail to correct their concept maps (ie, the modifications on the concept maps are incorrect and hence the scores do not increase), the system will provide the students more hints. However, if the students fail to improve their concept maps the second time, the system will record their status and ask for help from the teacher or the teaching assistant.

Auto scoring mechanism for ICMLS

This study employs a concept map assessment mechanism based on the weighted proposition approach proposed by Chang, Sung, Chang and Lin (2005). A proposition is composed of two concepts and the conjunction between them. In this study, the weighting value of a proposition ranges from 0 to 1. An illustrative example of a weighted concept map provided by the domain expert (teacher) for describing the concept ‘Heart failure’ is described in Figure 4.

The score for a student’s concept map is derived by comparing each of its propositions with the corresponding proposition in the teacher’s concept map. If the two propositions are the same, the weighting of the proposition is added to the accumulated score for the student’s concept map. If the two propositions are partially matched, only half of the weighting is added to the accumulated score. The final Concept Map Score (CMS) for Student S_i is calculated as follows:

$$\begin{aligned} CMS(S_i) = {} & (\Sigma \text{ weight value of students' proposition the accumulated score for } S_i) \div \\ & (\Sigma \text{ sum of proposition weightings value in the expert's concept map proposition}) \times 100 \end{aligned}$$

Considering the student’s concept map in Figure 5, the proposition ‘heart failure produced clinical features’ is the same as that given by the expert in Figure 4; therefore, the weighting of this proposition (ie, 1.0) in the expert’s concept map is added to the accumulated score. Similarly, for the proposition ‘left heart failure produced heart sounds’, the weighting 0.4 is added to the accumulated score. However, for the proposition ‘right heart failure was divided into forward and backward effects’, the student has used the wrong term; therefore, only half of the weighting (ie, 0.2) is added to the accumulated score. Moreover, the proposition ‘cirrhosis’ does not appear in the student’s concept map; therefore, no score is obtained for this proposition. Finally, the accumulated score for the student’s concept map is $1 + 0.8 + 0.4 * 2 + 0.2 + 0.1 * 3 = 3.1$ and the sum of weightings in the expert’s concept map is $1 + 0.8 + 0.4 * 4 = 3.4$; therefore,

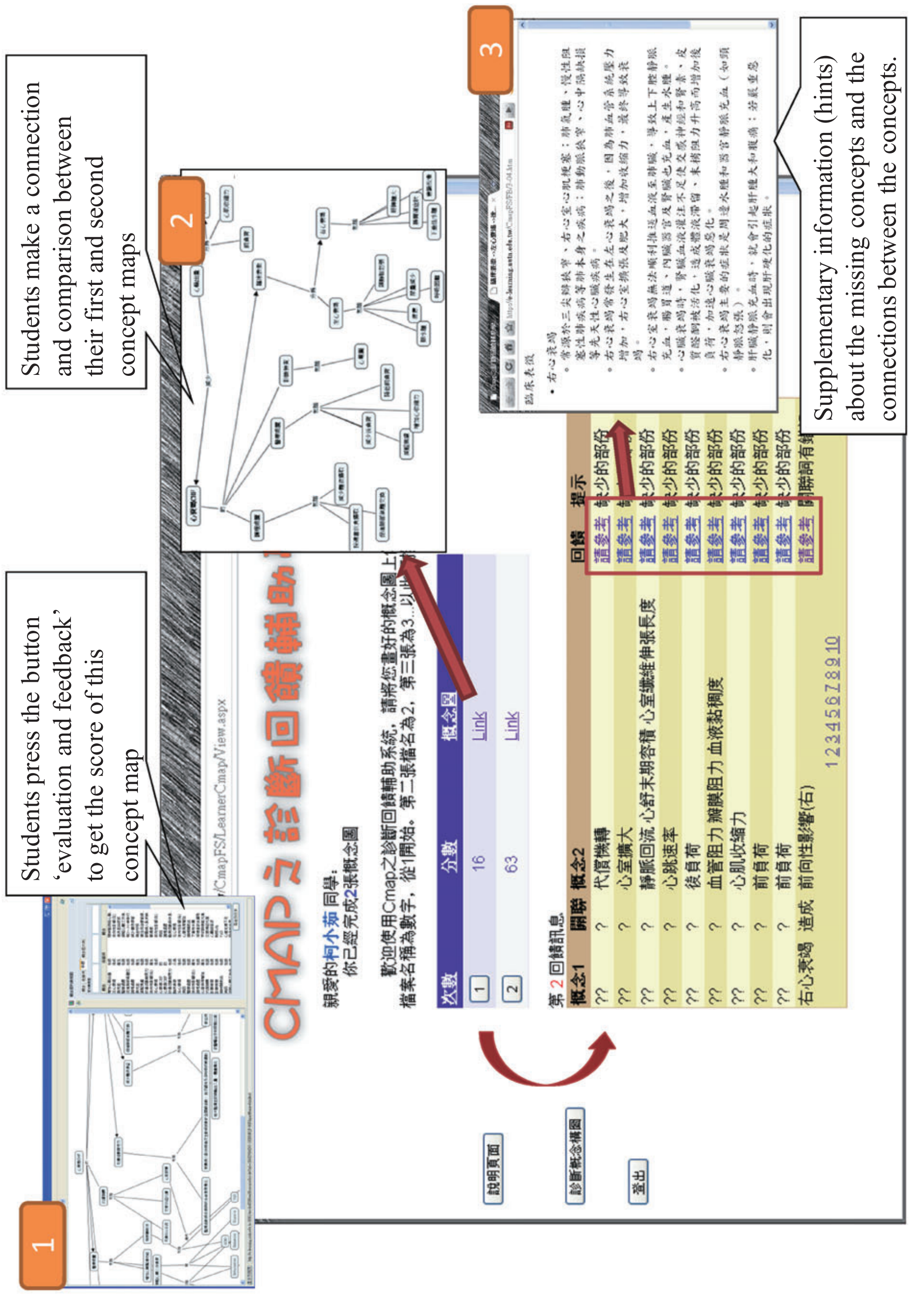

Figure 3: Illustrative example of the assessment and feedback system

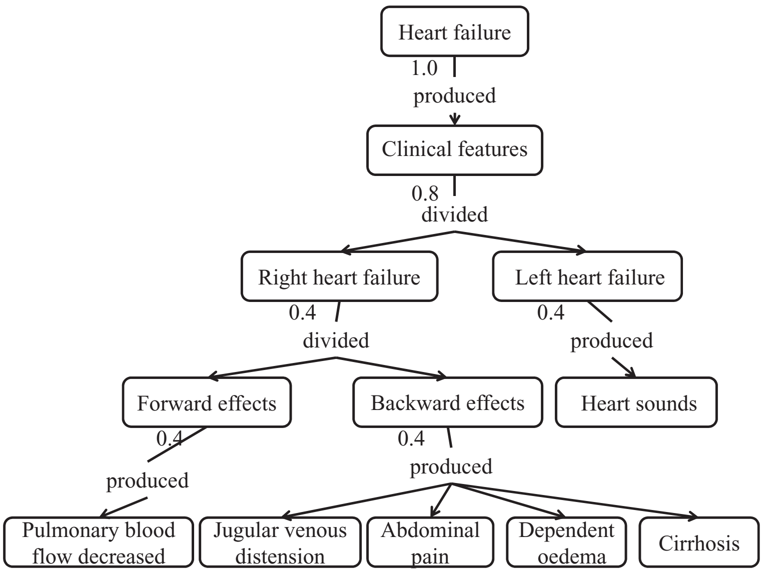

Figure 4: The weighted concept map provided by the domain expert

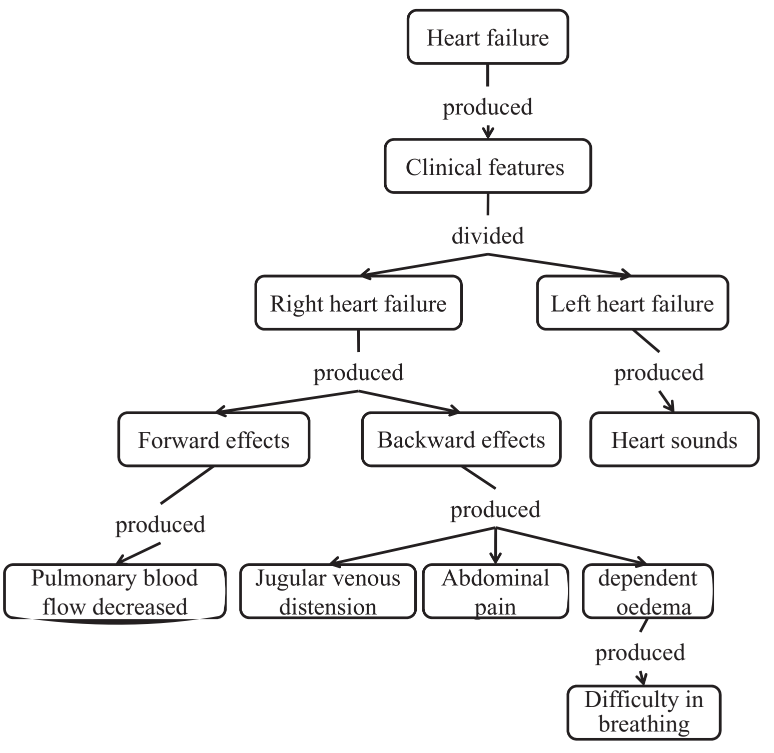

Figure 5: Illustrative example of a student's concept map

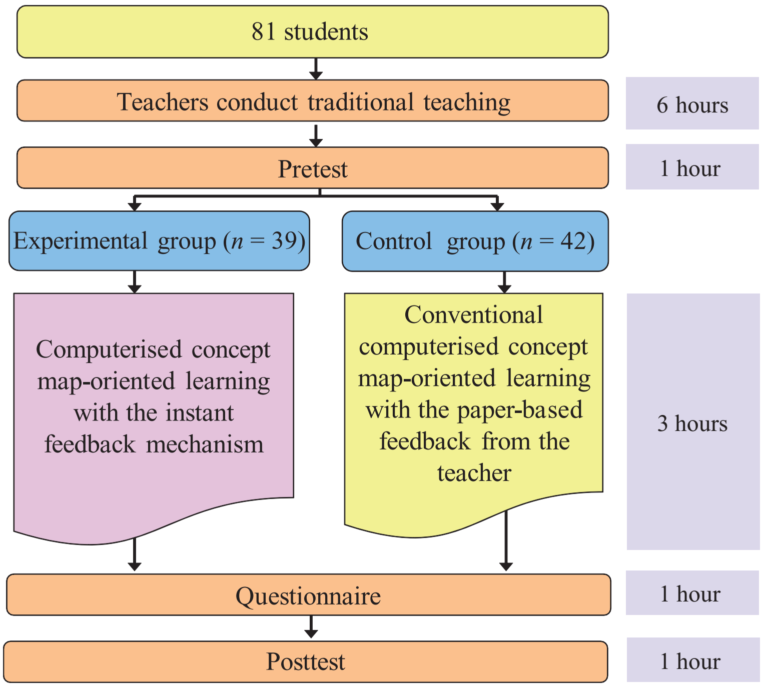

Figure 6: Procedure for conducting the experiment

CMS = (3.1/3.4) * 100 = 91. The CMS score will be presented to the student along with the hints and supplementary materials concerning the incorrect and incomplete propositions.

Experiment design

An experiment on a clinical nursing course has been conducted in order to evaluate the effectiveness of this innovative approach. In the learning activity of the course, the students are trained to practise what they have learned from the textbook in solving problems in the field, and recognise their role as caregivers (Woolley & Costello, 1988). In this experiment, ICMLS was applied to the 'Heart Failure' unit of a medical and surgical nursing course.

Participants

This study adopted a quasi-experimental design for non-equivalent groups. The subjects that participated in this study were two classes consisting of 81 final year students from the Nursing Department at a University in southern Taiwan. The average age of the students was 20 years old. One of the classes was assigned to be the experimental group ($n = 39$) and the other was the control group ($n = 42$).

Procedure

Figure 6 shows the procedure of the experiment, which was conducted during a period of 4 weeks, 3 hours per week, which resulted in 12 hours in total. In the first stage, the two groups of students took the 'Heart Failure' unit of the medical and surgical nursing course for 6 hours, and the computerised concept map training for 3 hours. In addition, a pretest was conducted to compare the prior knowledge of the two groups of students before the learning activity. The control group received paper-based feedback from the teacher before the posttest.

After the learning activity, a posttest was conducted to evaluate the learning achievement of the students. In addition, the questionnaires of learning attitude and technology acceptance (usefulness, ease of use and the feedback method of the learning system) were performed and analysed. It can be seen that the two groups of students were arranged to learn with the same length of time.

Treatments

During the learning activity, the students in the experimental group learned with ICMLS, while those in the control group learned with the conventional computerised concept map system. All of the students were taught by the same instructor who had more than 10 years experience in teaching that particular nursing course. The objective concept map was constructed by two experienced teachers in that school.

Measuring tools

The measuring tools in this study included learning achievement test sheets and questionnaires for evaluation of the learning situation. The test sheets were developed by two experienced teachers. The pretest aimed to assess the prior knowledge of the students before participating in the learning activity. It consisted of 20 multiple-choice questions (100%) related to the topic 'heart failure'. The posttest sheet included 10 multiple-choice questions (60%), five multi-select questions (15%) and four fill-in-the-blank questions (25%). It aimed to assess the learning achievements of the students for the content knowledge related to the learning activity.

The questionnaires concerning learning attitudes and technology acceptance were compiled by the researchers and presented with a 7-point Likert scale, where '7' represented 'strongly agree' and '1' represented 'strongly disagree'. The questionnaires were examined by four experts to reach a high level of reliability.

The 'learning attitude' questionnaire included two subscales: nine items for the 'attitude towards the learning approach' and five items for the 'attitude towards taking the course'. The Cronbach's alpha values of those two subscales were 0.94 and 0.92 respectively.

The questionnaire for the acceptance of using the ICMLS included two subscales: 12 items for 'the usefulness of the ICMLS' and four items for 'the ease of use of the ICMLS'. The Cronbach's alpha values of those two subscales were 0.96 and 0.87 respectively.

Furthermore, to evaluate the reliability of the CMS scores given by ICMLS, the concept maps developed by the students were assessed by two experts and ICMLS, and the Cronbach's alpha value was 0.99, implying that the scores given by ICMLS were highly consistent with those given by the experts; ie, the CMS scores given by ICMLS were reliable.

Analysis and discussions

Learning achievements

For the prior knowledge of the two groups before the experiment, the mean scores of the pretest are 73.33 and 70.29 for the experimental group and the control group respectively. According to the *t*-test result ($t = 0.74$, $p > 0.05$), no significant difference is found between the two groups. It is evident that the two groups of students had equivalent abilities prior to taking this unit.

For the learning achievements of the two groups after the experiment, the mean score of the experimental group, 72.17, is higher than that of the control group, 62.73. The *t*-test result reveals a significant difference between the two groups ($t = 3.26$, $p < 0.05$), as shown in Table 1. It can be noticed that the concept map-oriented learning system with the instant feedback mechanism seems to be more effective than the ordinary computerised concept map system in promoting the learning achievements of the students.

During the learning activity, the students in the control group learned with the conventional computerised concept map system. It usually takes days or weeks for teachers to manually

Table 1: t-test result on the posttest scores

		n	*Mean*	*SD*	*t*
Posttest	Experimental group	39	72.17	10.59	3.26*
	Control group	42	62.73	14.93	

*$p < 0.05$.
SD, standard deviation.

evaluate the concept maps developed by the students; consequently, the students cannot receive feedback from the teachers in time, which not only affects their learning schedules, but also significantly influences their learning achievements. On the contrary, the students in the experimental group received instant feedback from the learning system, and hence, derived significantly better learning achievements. This finding conforms to the findings of previous studies that have indicated the effects of immediate feedback on the improvement in learning achievements and the motivation of students (Narciss & Huth, 2006).

Moreover, from the records of the learning system, it is found that most of the students in the experimental group made several attempts in revising their concept maps. Moreover, it is interesting to find that the hints about the missing concepts or connections have motivated the students to read the supplementary materials which contain the information for improving their concept maps, and hence, correct modifications were consequently made. On the other hand, the students in the control group spent less time on reading those supplementary materials, such that they failed to make correct modifications most of the time or even gave up the opportunity to make modifications although they were provided with the supplementary materials. Those findings conform to what Denton *et al* (2008) have indicated; ie, the challenges for returning meaningful and instant feedback to individual students are due to the difficulties in finding a way to effectively and efficiently assess the work of the students and providing structured feedback that points out their misunderstandings or missed concepts and shows them the hints or guidance about what follow-up work are required. In this study, the CMS kept the student informed about their learning status and the hints motivated and guided them to find the required knowledge from the supplementary materials, as well as to develop new learning strategies.

Considering the relationship between the assessment time and the CMSs given in Figure 7, it was found that the more times the students revised their concept maps and received feedback from the learning system, the better CMSs they got. Therefore, it can be seen that real-time evaluation with instant feedback is very helpful to the students in improving their knowledge structures. This finding conforms to what has been reported by previous studies concerning instant feedback (Chu, Hwang, Tsai & Tseng, 2010; Hwang, 2003).

Learning attitudes

For the dimension of learning attitudes, the students were positive about the computerised concept map assessment and prompting system. The mean score of the questions, 5.06 (on a 7-point scale), represents that the students gave positive evaluations of the computerised concept map assessment and prompting system in learning, as shown in Table 2.

For the learning attitude of the two groups after the experiment, the mean score of the experimental group, 5.06, is higher than that of the control group, 4.65. The *t*-test result ($t = 2.31$, $p < 0.05$) reveals a significant difference between the two groups, as shown in Table 3. It can be seen that the concept map-oriented learning system with the instant feedback mechanism is more effective than the conventional computerised concept map approach with regard to the learning attitudes of the students.

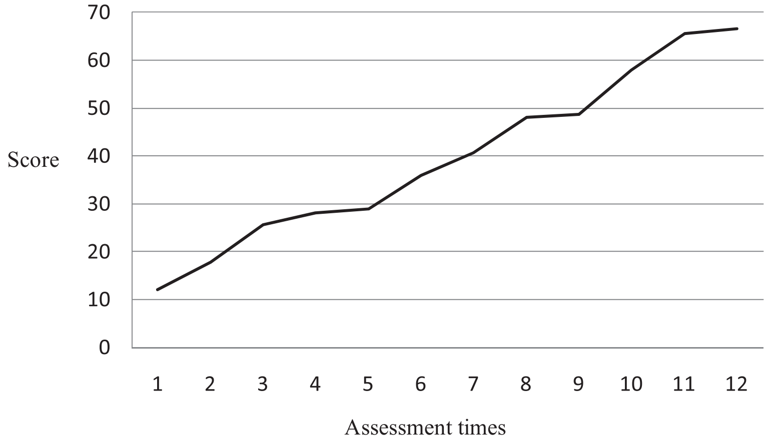

Figure 7: Curve of knowledge transformation

Table 2: Analysis of questionnaire of learning attitude

Questionnaire item	*Mean*	*SD*
About the learning approach	5.22	1.25
1. I think this learning approach enables me to immediately understand why my concepts are incorrect.	5.38	1.23
2. In the learning process, I can carefully read the information provided by the system to continue the learning activity.	5.51	1.10
3. This learning approach makes the current learning activity more challenging than the ones before.	5.44	1.27
4. I think this learning approach can help me learn the contents from a new perspective.	5.64	1.04
5. I like the learning approach adopted in this learning activity.	5.00	1.41
6. I expect to learn other subjects with this learning approach.	4.95	1.19
7. I hope to employ this learning approach and these tools in future learning activities.	5.00	1.38
8. I will recommend this learning approach to other classmates.	4.92	1.26
9. I think this learning approach makes this learning activity more interesting.	5.13	1.36
About taking the course	5.32	0.91
10. After taking this course, I want to know more about disease symptoms in nursing.	5.26	0.97
11. After taking this course, I want to know more about treatments in nursing care.	5.36	0.90
12. After taking this course, I am more concerned about the pathological state of future patients.	5.41	0.82
13. I will actively learn nursing knowledge in the future.	5.41	0.79
14. This learning approach makes me like nursing courses more than before.	5.15	1.09

SD, standard deviation.

Table 3: Analysis of the learning attitude questionnaire

		n	*Mean*	*SD*	*t*
Learning attitude	Experimental group	39	5.06	0.83	2.31*
	Control group	42	4.65	0.73	

*$p < 0.05$.
SD, standard deviation.

Table 4: Analysis of learning activity and course learning

		n	*Mean*	*SD*	*t*
Learning activity	Experimental group	39	4.79	0.96	2.69*
	Control group	42	4.27	0.79	
Course learning	Experimental group	39	5.32	0.80	1.50
	Control group	42	5.04	0.87	

*$p < 0.05$.
SD, standard deviation.

Table 4 shows the analysis results of the student's attitudes towards the learning activity and the course. For the aspect of the learning activity, the experimental group showed a significantly better attitude than that of the control group ($t = 2.69$, $p < 0.05$). Moreover, for the attitude towards taking the course, the mean score of the experimental group (ie, 5.32) is higher than that of the control group (ie, 5.04), although their difference was not significant ($t = 1.50$, $p > 0.05$).

Acceptance of technology

For the dimensions of usefulness and ease of use, the mean scores of the questions are 5.05 and 4.88. This represents that the students evaluated the usefulness and ease of use of the system positively, as shown in Table 5.

For the acceptance of the learning system of the two groups after the experiment, the mean score of the experimental group, 5.19, is higher than that of the control group, 4.62. The *t*-test result ($t = 2.86$, $p < 0.05$) reveals a significant difference between the two groups, as shown in Table 6. This implies that the innovative approach makes the concept map-oriented learning system more acceptable to the students since they are able to receive feedback and try again immediately.

Table 7 shows the *t*-test results for the 'usefulness' and 'ease of use' scores of the two groups after the experiment. For the 'usefulness' aspect, the mean score of the experimental group, 5.05, is higher than that of the control group, 4.69. According to the *t*-test result ($t = 2.06$, $p < 0.05$), it is found that the students in the experimental group gave significantly higher ratings than those in the control group for the dimension of 'usefulness'. Moreover, for the aspect of 'ease of use', the mean scores are 4.88 and 4.11 for the experimental group and the control group respectively. The *t*-test result ($t = 2.94$, $p < 0.05$) also showed that the students in the experimental group gave significantly higher ratings than those in the control group. Consequently, it can be concluded that the concept map-oriented learning system with the instant feedback mechanism is much more acceptable to the students than the conventional computerised concept map system.

Discussion

The provision of feedback has been identified as being a key for enhancing students' motivation, learning, reflection and understanding, as well as narrowing the gaps between their performance levels and the reference level (Orsmond, Merry & Reiling, 2005). Researchers further reported that the provision of timely feedback is very critical for maintaining the learning motivation of students (Gibbs & Habeshaw, 1993; Ypsilandis, 2002). It was found that students could lose interest to take feedback and continue to learn if the feedback is provided after days or weeks (Gibbs & Habeshaw, 1993).

One of the salient contributions of this study is the introduction of an instant assessment and feedback mechanism for improving the effectiveness of computerised concept maps. This approach differs from previous efforts that used only computerised concepts maps in many studies and practical applications but without providing an instant feedback. Another contribution of

Table 5: Analysis of the acceptance of the learning system questionnaire

Questionnaire item	*Mean*	*SD*
Usefulness	5.38	1.06
1. Using this learning system enables me to better understand the learning content.	5.49	1.10
2. I think this learning system can assist me to discover my personal learning problems.	5.54	0.91
3. The functions provided by this learning system help me organise and understand the knowledge acquired from this course.	5.67	0.93
4. Using this system in learning enables me to think differently about the learning content.	5.51	1.05
5. The functions provided by the system are beneficial to my learning achievement.	5.36	0.99
6. I have a deeper understanding of the learning content via the feedback provided by the learning system.	5.31	1.13
7. The feedback provided by the learning system helps me systematically understand the acquired knowledge from this course.	5.26	1.10
8. Using the feedback provided by the learning system enables me to concentrate on learning.	5.31	1.20
9. The feedback provided by the learning system can help me discover my personal conceptual myths in nursing.	5.36	1.09
10. The feedback provided by the learning system can assist me to efficiently modify the incorrect concepts.	5.18	1.17
11. The feedback offered by this learning system enables me to understand the parts I do not learn well.	5.33	1.03
12. The feedback provided by the learning system is beneficial for improving my learning achievement.	5.28	1.07
Ease of use	4.88	1.42
13. It is easy to operate the interface of this learning system.	4.66	1.62
14. It is easy to read the information given by the learning system on a PDA screen.	4.95	1.36
15. The contents presented by the learning system are appropriate for learning.	4.87	1.40
16. I can learn to operate this learning system in a short time.	5.10	1.29

SD, standard deviation.

Table 6: Analysis of the acceptance of the learning system

		n	*Mean*	*SD*	*t*
Acceptance of the learning system	Experimental group	39	5.19	0.95	2.86*
	Control group	42	4.62	0.84	

*$p < 0.05$.
SD, standard deviation.

Table 7: Analysis of usefulness, ease of use about the feedback mechanism of the learning system

		n	*Mean*	*SD*	*t*
Usefulness	Experimental group	*39*	*5.05*	*0.85*	*2.06**
	Control group	*42*	*4.69*	*0.71*	
Ease of use	Experimental group	*39*	*4.88*	*1.19*	*2.94**
	Control group	*42*	*4.11*	*1.18*	

*$p < 0.05$.
SD, standard deviation.

this study is to demonstrate how the proposed innovative approach can be used in a specific learning activity and to show its potential in terms of its effectiveness in improving the learning achievements, knowledge structures, learning attitudes and technology-acceptance degrees of the students.

In most previous studies, concept maps were mainly used as a tool for helping students to organise their knowledge. Researchers have indicated that learning improvements are difficult for individuals who are not aware of their shortcomings (Kao, Lin & Sun, 2008; Hwang, Shi, & Chu, in press); ie, the provision of instant feedback could be helpful to students in order to assist them on how to reflect on to revise their knowledge structures. Therefore, the approach proposed in this study could be a good reference for those researchers and teachers who plan to use concept maps in practical applications. These findings also show the value of investigating the possibilities of developing instant assessment and feedback mechanisms for other computerised learning strategies or tools.

In addition, it is interesting to point out that the experimental group students not only made significantly better progress in their learning achievements, but also showed better attitudes towards learning the course and using the learning system. The highest scored questionnaire item concerning the acceptance of the learning system was 'The functions provided by this learning system help me organise and understand the knowledge acquired from this course.' Moreover, from the analysis related to the usefulness and the ease of use of the feedback mechanism of the learning system, it was found that the experimental group gave significantly higher ratings than those students in the control group. Referring to the pretest and posttest scores, this study indicates that the instant feedback mechanism did motivate the students and help them improve their learning achievements.

It is also important to emphasise and to discuss the limitations of applying the instant assessment and feedback approach. It is assumed that both the auto-scoring mechanism and the feedback mechanism work well for assessing the concept maps developed by the students and give them helpful feedback. If the teachers are unable to provide good 'objective concept maps' or supplementary materials, the performance of the learning system could be disappointing. Such a problem could be addressed by applying the computer-supported collaborative tutoring, ie, developing the object concept maps and supplementary materials supported by collaboration coming from multiple experts. This latest approach has proven to be effective in several educational settings and applications (Panjaburee *et al*, 2010).

Conclusions

This paper presented the results of a study in which we used a computerised concept map-oriented learning system, ICMLS, with an instant feedback mechanism for supporting meaningful learning in medical and surgical nursing. With this innovative approach, the students are able to receive immediate feedback to help them revise their concept maps. In such an evaluation-feedback-modification cycle, the students are able to reorganise and improve their nursing knowledge. It was found that the enhanced concept map-oriented learning system significantly improved the learning achievements of the students. Moreover, the questionnaire survey showed that the students who learned with the new approach gave significantly higher ratings than those who learned with the conventional computerised concept map approach in terms of their learning attitudes towards taking the course and degrees of accepting the learning system.

In the near future, we plan to investigate in depth how this innovative approach benefits the students in medical and surgical nursing courses, in which it is important for the students to experience quality clinical practice so that their learning and retention in nursing can be enhanced (Kuen, 1997). In traditional clinical nursing courses, it is almost impossible to provide personalised assistance for individual students owing to the insufficient number of teachers and teaching assistants (Bernard & Cathryn, 2006). Researchers have indicated that most nursing school students are not well prepared for clinical nursing (Hautala, Saylor & O'Leary-Kelley, 2007; Watson, 2000). One of the reasons for these results is the lack of a systematic way of presenting their knowledge in a well-structured manner. With an increasing demand for nursing professionals, how to promote the quality and effectiveness of nursing education has become an important issue (Chang, Sheen, Chang & Lee, 2008; Guo, Chong & Chang, 2007; Wu & Lai, 2009). Such a need implies that an instant feedback mechanism could be an effective tool for easing the load of the teachers and the teaching assistants.

Furthermore, we plan to do more statistical analysis on the questionnaires regarding the aspects of learning attitude and use of the system (usefulness, ease of use and the feedback method of the learning systems) to compare the feedback from the students with different learning styles and cognitive styles; moreover, the cognitive load of the students will be investigated as well. In order to further validate the proposed approach, we plan to modify the learning system and to use it in natural science courses in elementary schools. The particular field of investigation will be related to field studies in environmental science using mobile and ubiquitous technologies. In this particular setting, we plan to investigate the effectiveness of our approach in helping students organise the data collected in the field and how to relate and structure this information to the real-world phenomena they will be exploring.

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