Winter 12-4-2009

Intelligent E-Learning System with Personalized Misconception Diagnose and Learning Path Guidance

Ling-Hsiu Chen

Yi-Chun Lai

Yi-Hsu Weng

INTELLIGENT E-LEARNING SYSTEM WITH PERSONALIZED MISCONCEPTION DIAGNOSE AND LEARNING PATH GUIDANCE

Ling-Hsiu Chen [1], Yi-Chun Lai [2], and Yi-Hsu Weng[3]
Department of Information Management
Chaoyang University of Technology, Taiwan (R.O.C.)
[1]ling@cyut.edu.tw; [2]s9614612@gmail.com; [3]s9714607@cyut.edu.tw

Abstract

In recent years, to advances network technology, IT-enabled learning and support learning are important in on-line education. More learners obtain knowledge by the Web-Learning Instruction (WBI). Learners usually induce the problem of misconception and cognitive overload when they use Web-based learning system. At present, most of the studies in the on-line education either concentrate on the technological aspect (e.g. personalization technology development) or focus on adapting learner's interests or browsing behaviors, while, learner's ability and level of knowledge is neglected. Therefore, it is important to consider learner's ability while designing web-based learning system. This study developed an On-line Knowledge Diagnose System (OKDS) to diagnose learner's misconception and provide personalized remedial guidance that based on a graphic organizer technology - concept map. The results indicate that the OKDS can effectiveness enhance learners learner's learning performance and learner also has positive perception of OKDS.

Keywords: concept map, web-based learning system, personalization remedial learning guidance.

Introduction

In decade years, as numerous web-based tutoring system have been developed, and many researches have tried to aid more efficient learning [1] [2] [4] [7] [9] [8] [11] [12] [13]. In order to aid more efficient learning, many powerful personalized and adaptive guidance mechanisms (i.e. adaptive presentation, adaptive guidance path support, curriculum arrangement, and artificial intelligence analysis of learner's solutions) have been proposed to improve learner's learning performance [1] [2] [4] [8] [11] [12]. While, most personalization adaptive systems focus on learner's interests or browsing behaviors but neglect learner's ability and level of knowledge [8] [11]. Several researches proposed to consider learner's level of knowledge in designing adaptive learning system [1] [2] [4] [8]. One way to present learner's level of knowledge is to organize learner's knowledge structure by the technologic of concept map [3] [6] [10]. Concept map can both present the relationship between concepts and the order and degree of different characteristic (i.e. hierarchical structure or sequential specialization) among concepts. In addition, concept map is appropriated to present structure of knowledge and diagnose misconception.

The most common way to discover misconception is to compare the concepts difference between expert and novice. Therefore misconception exists either in the situation of the expert has but the novice without or the expert without but the novice has. Previous studies based on the teacher-center mode to diagnose and discover learner's misconceptions and learning barriers focus on the situation of expert has but novice without [2] [4]. While, they omitted other type of misconception that novice has but expert without. To understand learner's misconception completely and then provide individualized service this study develops an intelligent e-learning system based on student-center mode to diagnose learner's misconception and provide personalized remedial learning guidance to improve learner's learning performance.

System Architecture and Components

To reach the completely misconception diagnose and provide remedial learning guidance, the study applied PHP to develop the Online Knowledge Diagnose System (OKDS) that based on the concept map model. The system architecture is shown in Figure 1. The OKDS includes six intelligent agents and three databases. The six intelligent agents are the learning interface agent, interface management agent, test questions management agent, pre-test process agent, post-test process agent and remedial learning path generate agent respectively. Three databases include the user account database, test questions database and misconception database.

The interface management agent and test questions management agent aims at providing a flexible managing interface. The system managers can use it to design the corresponding concept and weight of each test questions. The learning

interface agent aims at providing a flexible interface for learners to interact with the pre-test process agent, personalized remedial learning path generate agent and post-test process agent. The pre-test process agent aims to generate a test questions for the learner to determine the misconception of individual learner according to the diagnose results. In the meanwhile, the pre-test process agent will pass these misconceptions to the remedial learning path generate agent to establish personalized remedial learning path based on the proposed misconception diagnose approach. Moreover, the post-test process agent provides a final test while the learner finished the whole remedial learning process. The test questions management agent will provide a responsive test questions for individual learner. This agent also can aid system manager to create new test questions and course unit concepts, upload, delete or modify test questions from the test questions database.

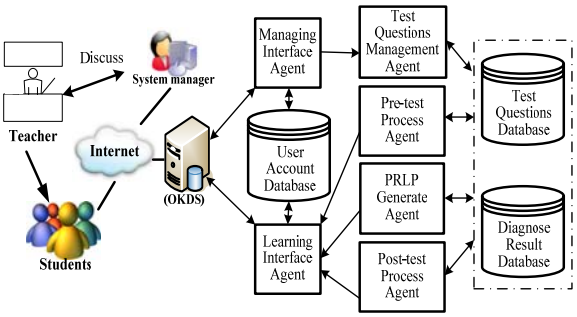

Figure 1: The System Architecture of the Online Knowledge Diagnose System (OKDS)

System Operation Procedures

Based on the above-mentioned system architecture, the system operation procedures are briefly described as follows (the complete operation procedures as shown in Figure 2):

Step 1-2: The test questions and the structure of concept map of learning materials were constructed by teacher and system manager and stored in the test questions database. Next, the threshold of Correct Ratio (CR) for each concept was created by teacher.

Step 3: The students were assigned to either experiment group or control group:

(1)Experiment group: This group of students was received grade, correct rate and personalized remedial learning path after they finished their pre-test process.

(2)Control group: This group of students just received grade and correct rate when they finished their pre-test process.

Step 4: Teacher teaches the learning material in the traditional classroom.

Step 5: Students login the OKDS through the learning interface agent by the users' accounts. After a student login in the OKDS, the learning interface agent will check it whether his/her account be stored in the user account database.

Step6-7: If the student has already owned a registered account, the OKDS request the student to conduct pre-test, the result will transfer to the pre-test process agent.

Step8: The pre-test process agent analyzes the pre-test results and conveys the misconception database. Furthermore, the remedial learning path generate agent establishes personalized remedial learning according to the diagnose result stored in the misconception database. At the same time, the personalized remedial learning path generation agent submits a learning guidance to students for further remedial learning.

Step9-11: After, the students finished the entire remedial learning provided by the personalized remedial learning path generate agent, the post-test process agent generate a test question to the student for performing a post-test to evaluate the learning performance.

Step12: The students asked to finish satisfaction questionnaire.

Step13: The system mangers analyzed the results of pre-test, post-test and student's misconception information for teacher.

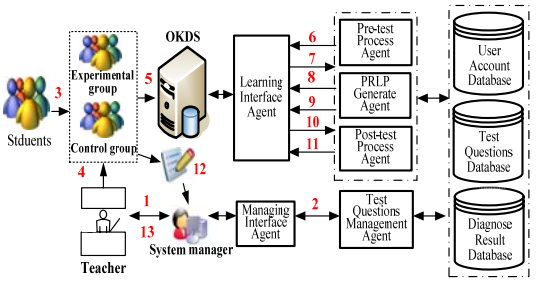

Figure 2: Flow Chart of Entirety Experiment

Research Approach

Constructing the Structure Map of Conceptual Relationship of Subject Materials

This study proposed a novel approach based on the Concept Map model. To construct the structure of conceptual relationship, the structure map can view a blueprint of overall key concepts as shown in (Figure 3). In Figure 3, the structure map includes stratum and priority of overall key concepts. This structure map can offer an overall concept relationship for each course unit and also provide a diagnosed based for each student's to understand student's learning status. For example, if a student

fails to learn the concept C3, we will presume that this student did not learn well in concept C3. Then

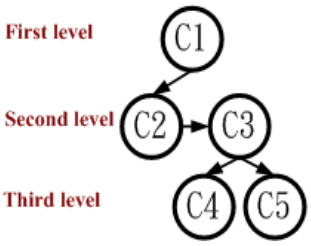

Figure 3: The Structure Map of Conceptual Relationship of Subject Materials

Designing Threshold of Correct Ratio (CR) and Conceptual Weight of Test Questions

In the domain of programming course, the test questions not only include one concept it usually contain two or more concepts in a question. Therefore, when we construct the relationship among a question and Concepts the Weight of each concept (CW) in a question must predefine. If a test question comprises a single concept, the CW will be expressed by "1". If a test question comprises two or more concepts, the range of CW is less than 1 and the sum of the CW is 1. In addition, each value of CW(Cj) denotes the total strength of concept Cj; CORRECT(Cj) is the total strength of the correct answers which are related to Cj; and CR(Cj) = CORRECT(Cj) / CW(Cj) represents the ratio of correct answers to the total strength of concept Cj (Table 1).

Table 1: The Comparison of Designing of Conceptual Weight of Test Questions

Question	Concept				
	C1	C2	C3	C4	C5
Q1	-0.25	0.25	0	0.25	-0.25
Q2	0	0.25	-0.25	-0.25	-0.25
Q3	0.25	-0.25	0	-0.25	0.25
Q4	0.5	0.25	0	0	0.25
Q5	0	0.25	0.25	0.25	0.25
CW	1	1.25	0.5	1	1.25
CORRECT	0.75	1	0.25	0.5	0.75
CR(Cj)	75%	80%	50%	50%	60%

In this section, we present a new approach to diagnose learner's misconception base on the Concept Map model. The flow chart of misconception diagnosis is presented in Figure 4. The correct ratio (CR) for concept 1 is 75% (CR(C1)= (0.25+0.5)/1=75%), concept 2 is 80% (CR(C2)=(0.25+0.25+0.25+0.25)/1.25=80%), concept 3 and concept 4 are 50%, and concept 5 is 60%. If the threshold (γ) is 60% we can find that two concepts' (C3 and C4) CR value less than 60% therefore this student has misconception on C3 and C4. Figure 4 is the flow chart of the process of this system will suggest this student to learn C2 thoroughly before he/she go to concept C3. misconception diagnosis.

This study allows more than one answer in the test questions and different weight for every concept on correct option. The examples will illustrate in Table 2.

Establishment of Personalization Remedial Learning Path

At the same time, the system establishes a Personalization remedial learning path for the student in accordance with the structure and relationship of concept map. The flow charts of the process to establish personalization remedial learning path is presented in Figure 5.

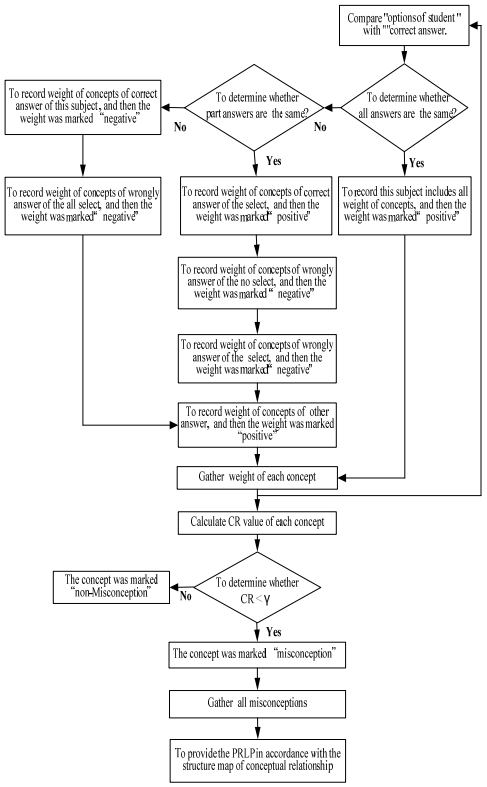

Figure 4: Flow Chart of Diagnosis of Misconception

Table2: The Illustrative Example of Test Questions in This Study

No	Question	Weight of each option	correct answer
Q1	Which is the correct option? (A)Constructor is a method. (B) The object can't automatically call constructor when the Object be produced. (C)Each Constructor have a Constructor of default. (D)The Constructor can accept the parameters.	(A)C1=0.25 (B)C2=0.25 (C)C4=0.25 (D)C5=0.25	AC

According to the previous section this student

has misconception on C3and C4. According to the concept map that constructed in Figure 3, C3 and C4 belong to different learning level (C3 is located in the second level and C4 belong to the third level). Hence, this learner's remedial learning path was constructed based on the order of learning level (from the lower level to the higher level), therefore the personalized remedial learning path for this student is C3→C4

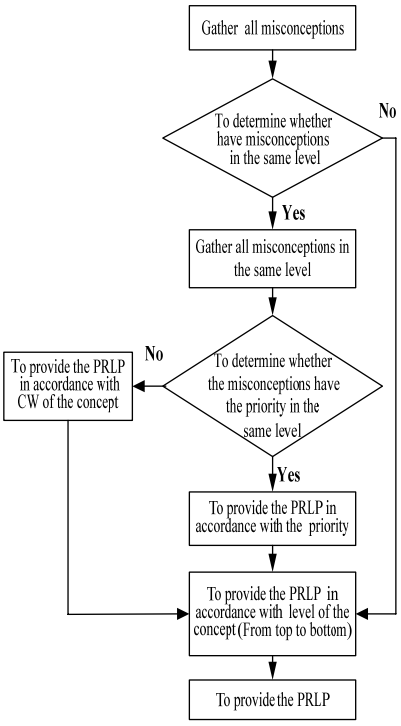

Figure 5: Flow Chart of Personalization Remedial Learning Path

Experiments

The detailed experimental design in this study is described as follows.

Experiments Design

This study conducted a true experimental design (pretest-posttest control group design) to review the validity of the treatment. The true experimental design is excellent in showing a cause-and-effect relationship, and random assignment controls for extraneous variables. In addition, the true experimental design has a high internal validity. Therefore, true experimental design is very beneficial to verify the effectiveness for our system.

This study used java programming course to evaluate the efficacy of our system. There are 45 first-grade university students participated in this study. In addition, all 45 students conducted two tests (including a pre-test and a post-test).

The Implemented Online Knowledge Diagnose System

To illustrate how to perform the learning processes using an established PRLP for an individual student, this section will introduces the diagnosis procedure on the implement OKDS. In Figure 6 shows the user's login interface, as a user logins the system. In Figure 7 shows the maintained interface of concepts for the system manager. In Figure 8 shows the maintained interface of test questions for the system manager. In Figure 9 shows the maintained interface of test question items for the system manager. In Figure 10 shows the interface of performing a pre-test for a student. After a student finishes a pre-test, the system will analyze the pre-test results, then the system will established a PRLP for an individual student, that can be designed to guide student in further learning. In Figure 11 displays the experimental group's interfaces that includes PRLP, correct ratio and spend time according to the diagnosis responses of an individual student. In addition, Figure 12 displays the control group's interface that includes correct ratio and spend time according to the diagnosis reposes of an individual student.

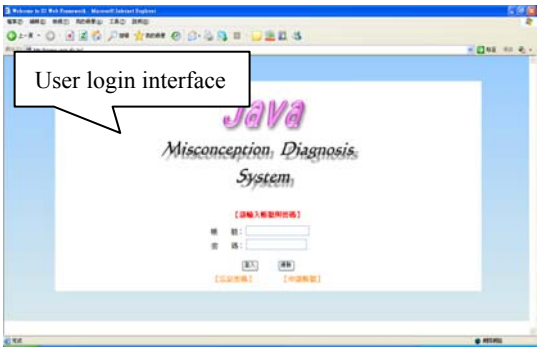

Figure 6: The User's Login Interface

Figure 7: The Maintained Interface of Concepts

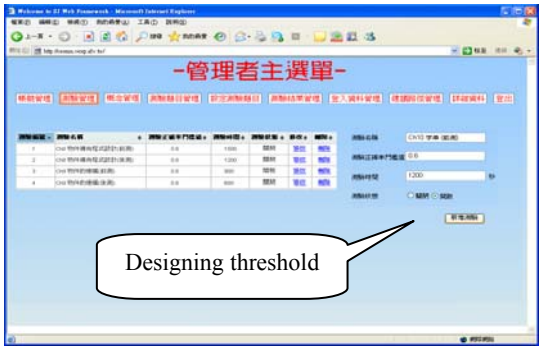

Figure 8: The Maintained Interface of Test Questions

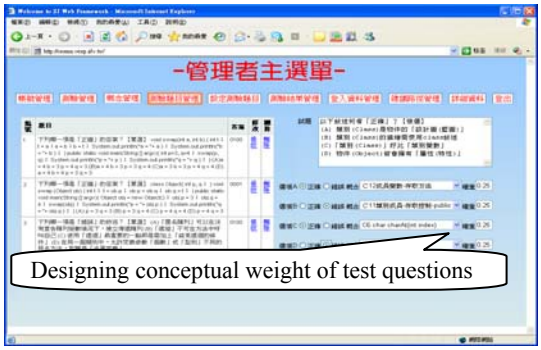

Figure 9: The Maintained Interface of Test Questions Items

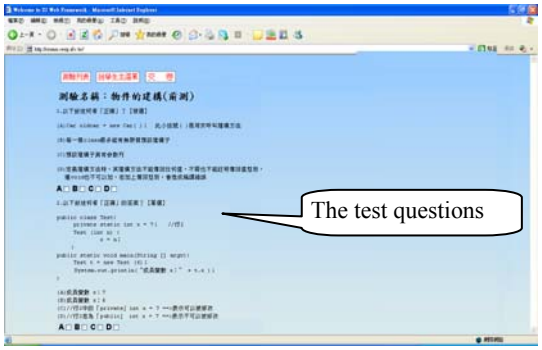

Figure 10: The Pre-test for a Student (Test Question)

Figure 11: The Experimental Group's Interface (Pre-test Result)

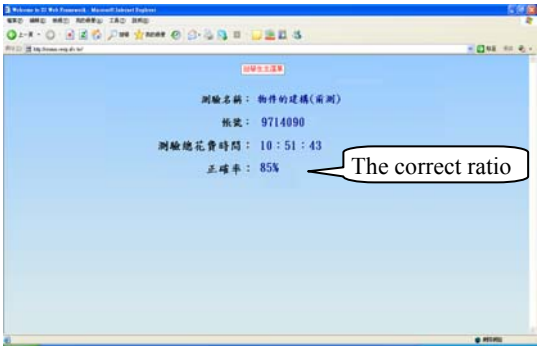

Figure 12: The Control Group's Interface (Pre-test Result)

Experiments Analysis

(1)Pre-test

The t-test values for the pre-test results as shown in Table 3. According to Table 3 experimental group and control group has not significantly difference in the pre-test score (p-value=0.962 > 0.05).

Table 3: T-test of Pre-test Results of Experimental Group and Control Group

group	Item				
	N	Mean	S.D.	t-value	p-value
Experimental group	21	40.47	10.44	0.048	0.962
Control group	23	40.30	13.13		
*p< 0.05					

(2)Post-test

The t-test values for the post-test results as shown in Table 4. The mean scores of the post-test clearly reveal that experimental group performed better than control group (Mean=68.23>Mean=58.91). Moreover, the p-value is 0.048, which implies that significant difference existed in the post-test (*p-value < 0.05). Therefore, we can conclude that experimental group performed significantly better than control group in the pre-test, conducted before performing the experiment. The significantly reach p-value=0.048. The result, we can conclude that experimental group achieved a better significant improvement compared to control group after receiving learning guidance via a novel approach of misconception diagnose on OKDS system.

Table 4: T-test of Post-test Results of Experimental Group and Control Group

group	Item				
	N	Mean	S.D.	t-value	p-value
Experimenta	21	68.2	14.75	2.036	0.048

l group		3	
Control group	23	58.91	15.54
*p< 0.05			

(3)Satisfaction Analysis

To understand student's satisfaction attitude toward the OKDS, this study conduct a survey by questionnaire. There are 53 students joined this survey, the valid respondents are 44. There are 9 respondents are invalid, 60% of respondents are male. The tester's age is from 15 to 19 years old. The educational background is under-graduated. There are 5 questions in our questionnaire, included learner's perception of helpful and satisfaction to the learning guidance function.

The experimental group gets significantly higher overall satisfaction than the control group does (Mean=20.05>Mean=16.57, p=0.000) as shown in Table 5. Similarly, in "Steps to learn a concept in the e-learning system follow a logic sequence" (p=0.012), "Using the e-learning service can improve my learning performance" (p=0.040), "The e-learning system provides the right learning guidance to me" (p=0.000), and "The e-learning system provides the individual learning guidance to my request" (p=0.000) the experimental group gets significantly higher scores than the control group does.

According to the result, we can find that experimental group has a significant positive perception compare to control group after receiving learning guidance via the OKDS.

Table 5: T-test of Satisfaction of Experimental Group (N=24) and Control Group (N=21)

Item	Group		t	P
	EG	CG		
1.Steps to learn a concept in the e-learning system follow a logic sequence	4.14	3.70	2.619	0.012*
2.Using the e-learning service can improve my learning performance	4.19	3.78	2.115	0.040*
3.I find the e-learning service to be useful to me	4.14	3.87	1.416	0.164
4.The e-learning system provides the right learning guidance to me	3.86	2.83	4.966	0.000*
5.The e-learning system provides the individual learning guidance to my request	3.71	2.39	5.207	0.000*
Overall satisfaction	20.05	16.57	5.725	0.000*

Conclusions

The research results of this study showed that students provided by personalized remodel learning path had significant progress and higher satisfaction with this system after taking the learning guidance. Consequently, we can conclude that the novel approach proposed by this study can help students to improve their learning performance. In the meanwhile, the results of satisfaction also showed the learners have a positive perception to this system. It implies that provided the PRLP not only can satisfied requirement of individualization, but also can provided a logic sequence in learning process, and can enhanced the learning performance and satisfaction of students. Furthermore, this study reveals the novel approach not only can reach exact misconception diagnose, but also can provide learning guidance properly. Moreover the novel approach also can as a new choice in the on-line knowledge diagnose system building.

Acknowledgments

The authors would like to thank the National Science Council of the Republic of China, Taiwan for financially supporting this research under Contract No. NSC98-2511-S-324-004-MY2.

References

[1] Chen, C. M., Lee, H.M., and Chen, Y. H. "Personalized e-learning system using item response theory," *Computers and Education*, 44, 2005, pp. 237-255.

[2] Hwang, G. J. "A concept map model for developing intelligent tutoring systems," *Computers and Education*, 40, 2003, pp. 217-235.

[3] Lambiotte, J. G., Dansereau, D. F., Cross, D. R., and Reynolds, S. B. "Multi-relational semantic maps," *Educational Psychology Review*, 1, 1989, pp. 331-367.

[4] Lee, C. H., Lee, G. G., and Leu, Y. "Application of automatically constructed concept map of learning to conceptual diagnosis of e-Learning," *Expert Systems with Applications (SCI)*, 36, 2009, pp. 1675-1684.

[5] Lockyer, L., Patterson, J., and Harper, B. "Measuring effectiveness of health education in a web-based learning environment: A preliminary report," *Higher Education Research & Development*, 18(2), 1999, pp. 233-246.

[6] Mintzes, J. J., Wandersee, J. H., and Novak, J. D. "Assessing understanding in biology," *Journal of Biological Education*, 35, 2001, pp. 118-124.

[7] Piaget, J., "The child's conception of movement and speed (G. E. T Holloway, trans.)", London: Routledge & Kegan Paul, 1970.

[8] Papanikolaou, K. A. and Grigoriadou, M. "Towards new forms of knowledge communication: The adaptive dimension of a web-based learning environment,"

Computers and Education, 39, 2002, pp. 333-360.

[9] Tu, C. T. "Application pathfinder network analysis on measurement of the knowledge structure," *Journal of Primary Education of Tainan Teachers College*, 13, 2000, pp. 275-306.

[10] Turns, J., Atman, C., and Adams, R. "Concept maps for engineering education: a cognitively motivated tool supporting varied assessment functions," *IEEE Trans on Education*, 43, 2002, pp. 164-173.

[11] Tang, T. Y. and Mccalla, G. "Smart recommendation for an evolving e-learning system: architecture and experiment," International Journal on E-Learning, 2005, pp. 105-129.

[12] Weber, G. and Specht, M. "User modeling and adaptive navigation support in www-based tutoring systems," *In proceedings of the sixth international Conference on user modeling*, 1997, pp. 289-300.

[13] Yu, M. N. "The study of online the assessment model of cognitive diagnostic: A Case Study of Low achievement students of mathematics of primary school," *N. S. Council*, Ed. China, Taiwan, 2001