A Web-based System Design for Enhancing Learning Problem Solving in Artificial Intelligence

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***Abstract*— The purpose of this paper is to present the design of a web-based system to enhance learning problem solving in artificial intelligence. The system design contains learner model, pedagogical model, domain knowledge model, communication model, expert model, and knowledge management model. The design is based on Robert Gagné's concepts of instructional theory and Intelligent Tutoring System (ITS) model based on rule based approach. The designed system can adapt learning and tests according to each learner's skill.**

***Keywords*—Adaptive learning, Adaptive testing, Problem solving, Web-based System Design**

I. INTRODUCTION

Learning to face-to-face (F2F) classroom teaching to the Internet is importance for all levels of the learner. As Internet technologies growing and expanding to increase the quality of higher education in ASEAN throughout globalization of education technology, developing a web-based learning may be not difficult without concept of instructional design. Nevertheless, effective design and development of a web-based learning system based on instructional theory, learning theory before design a lesson could lead to achieve quality of a web-based learning system.

Robert Gagné [1]'s nine concepts of instructional theory are popular in educators. So far, several web-based learning systems in computer science programme are implemented some parts of this theory (e.g. [2-5]). In addition, there is an evidence shows that several students could not catch up with problem solving in artificial intelligence in the classroom (by interviewing some undergraduate students in computer science and information technology major). Therefore, this paper addresses these weaknesses while developing a web-based learning support environment for globalization in higher education. Our paper introduces the architecture of a web-based system design to enhance learning problem solving in artificial intelligence. The system design contains learner model, pedagogical model, domain knowledge model, communication model, expert model, and knowledge management model. The goal of the system design is to provide the benefits of one-on-one instruction automatically and cost effectively. The domain knowledge of the system design consists of knowledge of basic methods for problem solving in artificial intelligence e.g. best-first search, greedy algorithm, and A* search algorithm [7]. The system is designed based on Robert Gagné's concepts of instructional theory and Intelligent Tutoring System (ITS) model [8] based on rule based approach. The designed system can adapt learning and tests according to each learner's skill. The next section is the related systems to our system design.

II. LEARNING SUPPORT PROGRAMS IN COMPUTER SCIENCE SUBJECTS

At present, several computer support programs can help the learner learn in subject matter of computer science [2-6].

Seaseng and Niyomdaycha [2] developed a tutoring program for learning computer base number conversion using a designed approach of computer assisted learning based on Gagnè [1]'s nine concepts. The contents in this program consist of conversion of base number (2, 8, 10 and 16) and the operations (addition, subtraction, multiplication, division) of each base number. The system efficiency is suit for deploying in the real situation. KERMIT [3], an intelligent tutoring prototype for undergraduate student in learning and training to build ER diagram ("Entity Relationship Model"), is developed using Microsoft Visual Basic run on Window Operating system. The system efficiency is suit for students to learn ER diagram. The learners satisfy in the intelligence of the system that can adapt to the learner competencies. Although the program has not taught Entity Relationship directly, the learner can practice/drill building ER diagram according to the prepared questions. CeeBot [4], developed by Roux, Dumoulin, Kölbl, and Walz, is a learning support program in C++, C#, and Java that provide learning environment in 3D animation. Current program consists of 4 versions. CeeBot is suit for primary/high school students, undergraduate students, and other people who prefer to learn/drill these programming languages. In the current version, CeeBot has not presented instruction for learning C++, C#, and Java directly; however; the learners can practice/drill coding a program for controlling a robot movement. Robomind [5], developed by Arvid Halma using Java, is a learning support program in basic programming. This program is implemented based on Logo programming language. Robomind supports the learner to understand basic of computer programming using technique in coding program to control a robot. The program was evaluated with 111 students (Grade 10) by teachers' suggestion while using the system. The result showed that the students' learning achievement is higher [9]. Chuinkeaw, et al. [6] developed a tutoring program for learning tree data structure based on Robert Gagné's concepts of instructional theory. The quality of developed program was good (evaluated by five experts) and could use the program to improve teaching and learning. The result of assessing program efficiency was acceptable; however, the program was needed to improve in the future according to all experts' suggestion.

According to the related support learning programs in major subjects in computer field (see Table 1), they were designed and developed in some concepts of Gagné's theory. Gagné's nine concepts are suit for designing instruction in computer assisted instruction, or web-based learning system. These concepts highlight the interaction between lessons and learners (e.g. stimulator, encouragement, etc.) to pay attention to the lessons and response to them. As mention earlier, this is the reason why we choose this subject matter; therefore, we select this idea in designing a web-based system for enhancing learning problem solving in Artificial Intelligence.

TABLE 1
A COMPARISON OF LEARNING SUPPORT PROGRAMS THAT RELATED TO MAJOR SUBJECTS IN THE FIELD OF COMPUTER SCIENCE IN WHICH SOME FEATURES OF THE PROGRAM IS CONSISTENT WITH GAGNÉ'S THEORY

Program / Gagné'sTheory	1	2	3	4
Gain attention	✓	✓	✓	✓
Specify Objective	✓	×	×	×
Activate prior knowledge	✓	×*	×	×
Present the content	✓	×	×	×
Guide learning	×	✓	×	×
Elicit performance	✓	✓	✓	✓
Provide feedback	✓	✓	✓	✓
Assess performance	✓	×*	×	×
Review and transfer	×	×	×	×

Program 1 = A Tutoring Program for Learning Computer Decimal Number Conversion [2]
Program 2 = KERMIT [3]
Program 3 = CeeBot [4]
Program 4 = Robomind [5]

✓ = some features of the program which is consistent with Gagné's theory
× = some features of the program which is not consistent with Gagné's theory

* = in the KERMIT evaluation, the researchers used paper tests for both pretest and posttest (not the tests that generated from the program)

III. GAGNÉ'S NINE CONCEPTS OF INSTRUCTIONAL DESIGN

According to Robert Gagnè [1], to design the system, we adopt Gagnè's nine events respectively that are needed for effective learning as follows.

A. Gain attention

There are several methods to grab the learner's attention to present a problem or a new situation. For example, storytelling, demonstrations, presenting a problem to be solved, doing something the wrong way (the instruction would then show how to do it the right way), telling why it is important, etc. To use this concept, we employ animation of each problem type in problem solving from the system's domain knowledge to motivate the learner to learn the lesson.

B. Specify Objective

Specifying objective can help the learner's to organize their thoughts. For example, describing the goal of a lesson, telling what the learners will be able to accomplish and how they will be able to use the knowledge. To utilize this idea in the system design, after the learner is motivated to learn then the system informs the specific objectives of each lesson to the learner.

C. Activate prior knowledge

Activating prior knowledge can help learners to build on their previous knowledge or skills. For example, reminding the learners of prior knowledge relevant to the current lesson, providing the learners with a framework that helps learning and remembering. To use this concept in the system design, the learner has to do overall pretest (for all lessons) before starting to any lessons and each pretest before learning each lesson.

D. Present the content

Sequencing the content or learning events by using Bloom [10]'s Taxonomy and Learning Strategies could help order the lesson. To apply this idea in the system design, the contents are presented as the methods in helping the learner to comprehend how to solve problem in artificial intelligence. To apply this notion, we propose three topics which are best-first search, greedy algorithm, and A* search algorithm.

E. Guide learning

These are instructions on how to learn but avoid mixing it with the subject matter, such as providing examples. To use this concept, we present the examples which are consistent with the contents while the learner is doing the exercises. This could help the learner understand the contents. We categorize the learner's understanding into three levels which are low, medium, and high. The system gradually increases the number of examples according to the level of each learner's understanding with five levels of contingent help [11].

F. Elicit performance

Practice by letting the learner do something with the newly acquired behavior, skills, or knowledge. For example, asking questions. To utilize this idea, the system asks the learner questions during learning the lesson. At this moment, if he/she could not answer a question, the system gradually shows the explanation and the number of examples according to the level of each learner's understanding with five levels of contingent help [11].

G. Provide feedback

This is providing specific guidance to show correctness of the learner's response, analyze learner's behavior from a test, quiz, or verbal comments. To employ this idea, during performing the exercises, the learner will be informed feedback based on Draper [12]'s three types of feedback. These are 1) explain to the learner what was "right"; 2) explain to the learner what was "wrong"; and 3) explain to the learner how to right the wrongs without "wronging the rights".

H. Assess performance

The posttest is utilized for determining if the lesson has been learned. This should be

followed by general progress information to the learner. To utilize this notion in the system design, the learner has to do overall posttest (for all lessons) after finishing to any lessons and each posttest after learning each lesson.

I. Review and transfer

This is the information to the learner about similar problem situations such as providing additional practice, taking the learner in a transfer situation, reviewing the lesson, etc. To apply this concept, we use skill meter [13] to report the learner's learning results of each topic (for each lesson) and of each lesson (for overall lesson) after the learner finishing each pretest, each posttest, overall pretest, and overall posttest. In the web page, the learner will be informed to review and return to study/learn the recommended topic or lesson which he/she weak.

IV. DESIGN OF A WEB-BASED SYSTEM FOR ENHANCING LEARNING PROBLEM SOLVING IN ARTIFICIAL INTELLIGENCE

Figure 1 shows the architecture of a web-based system for enhancing learning problem solving in artificial intelligence. There are six components in this architecture in which can be explained as follows.

A. Domain Model

Domain knowledge of problem solving in artificial intelligence is a part of tutor's information in teaching. This model contains concept of basic methods for problem solving in artificial intelligence. In the current system design, we present three techniques. These are best-first search, greedy algorithm, and A* search algorithm. This model also includes exercises banks and tests banks of these three methods.

B. Expert Model

Expert model stores the information in teaching which similar to the domain knowledge. It contains rules in solving problem of the learner's solution to compare with the expert's solution. This model utilizes rules for problem solving in best-first search, greedy algorithm, and A* search algorithm.

C. Pedagogical Model

The pedagogical model contains the processes of teaching i.e. the processes of when to teach/present a topic. This module receives information from learner model and expert model to process appropriate content to the learner. We present processes as rules in this model as follows.

1) Rules for providing feedback: These rules based on Draper [12]'s types of feedback.
2) Rules for tutor hints: These rules based on five level of contingent help [11].
3) Rules for Gagnè's nine concepts: These rules are used for controlling the process of presenting a topic to the learner.
4) Rules for tutoring best-first search algorithm [7].
5) Rules for tutoring greedy algorithm [7].
6) Rules for tutoring A* search algorithm [7].
7) Rules for adaptive learning: These rules are employed to adapt the number of examples/questions according to each learner's competency level (low, medium, high)
8) Rules for adaptive testing: These rules are applied to adapt the test items according to each learner's competency level (low, medium, high)

D. Learner Model

The learner model stores the information of each individual learner. For example, tracking the learner's performing on the system in order to record the learner's feedback to the system. In this model we record the number of accepting help from the

system (when trying to answer the right answer and ask for help from the system). In addition, we also record the number of refusing help from the system (when trying to answer the right answer but refuse help from the system). This model depends on time to reflect to the learner.

E. Communication Model

Communication model is the component that controls the communication among the learner, the instructor and the system via the dialogue and the screen layouts. This model employs a web-board that the learner can leave a question to the instructor and he/she answers to such question. This model consists of rules for dialogue response. For example, if the learner repeats taking into account the review of the learner's results (e.g. clicking the result's report button several times) more than three times in a moment, the system provides a help message to the learner.

F. Knowledge Management Model

The instructor and the learner can utilize this model. This model consists of managing module for contents, tests/exercises; module for searching tests/exercises; and module for searching/viewing learner's profile. These are the modules for the instructor while the learner employs module of managing learner's profile.

V. CONCLUSIONS AND FUTURE WORKS

In this paper we design a web-based system design for enhancing learning problem solving in artificial intelligence as shown in figure 1. The design approach could be a model in designing related systems which employ Gagnè's nine concepts and ITS model based on ruled based approach.

We believe that the implemented system could enable learners to practice their skills by carrying out tasks within highly interactive learning environments, like training simulations. In addition, it could help the learners improve their learning to problem solving in artificial intelligence. The result of the system deployment could be an innovation to contribute to the knowledge in design and implement an intelligence tutoring system, a computer support learning, eLearning mLearning, uLearning, etc. Researchers could use the results of the research to study and compare to other related researches in the related field. In addition, lecturers/instructors who teach in similar topic to problem solving in artificial intelligence could use the system to help the learners to improve their learning.

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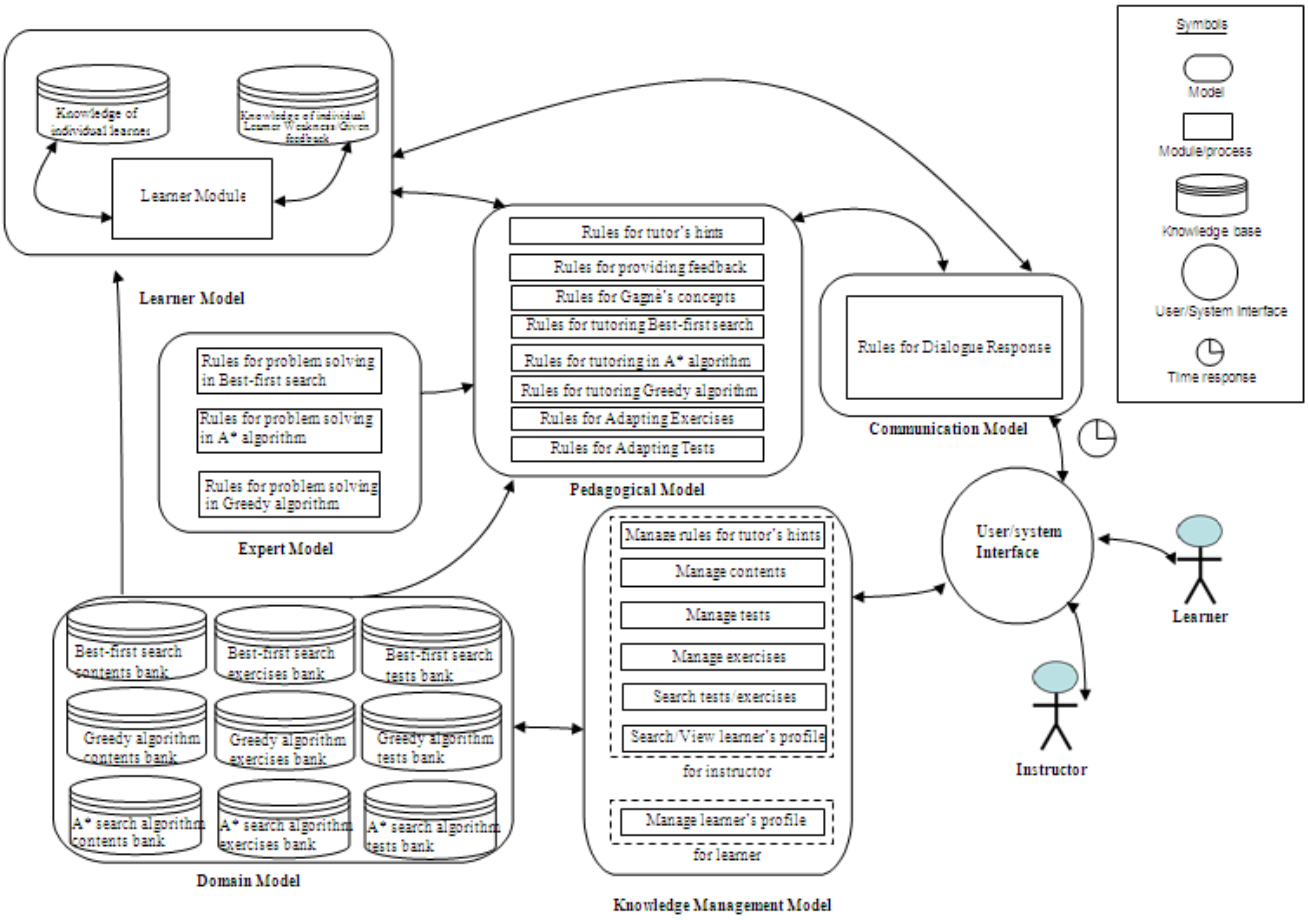

Fig. 1 Architecture of a web-based system design for enhancing learning problem solving in artificial intelligence.