Implementation of Cognitive Tutoring System

May Po Po Aye; Mi Mi Nge
University of Computer Studies, Yangon
naing.thakhin@gmail.com

Abstract

Now Intelligent Tutoring System (ITS) is used widely online learning and teaching. Intelligent tutoring system (ITS) is any computer system that provides direct customized instruction or feedback to students; i.e. without the intervention of human beings, while performing a task. Intelligent tutoring system implements the theory of social science. An intelligent tutoring system is presented for the domain of solving equation. In this paper, cognitive tutoring system is implemented for solving mathematical equations in computer graphic subject. There are two main parts in this system. One part is to instruct the whole theoretical concept by using with PowerPoint slides. Another part is to examine the understanding level of students. In this system, multiple choice questions are used to test the understanding level of theory concept and cognitive tutor is used to test the understanding level of mathematic equations
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Keywords: Intelligent tutoring system, cognitive model, tutoring, mathematical education, artificial intelligence

1. Introduction

Although the reach on Artificial Intelligence in Education (AI-ED) can be traced back to the 80's, when the first ideas an Intelligent Tutoring Systems (ITS) were introduced, presently it is going through an accelerated evolution process, mainly due to innovative computer technologies, such as hypermedia, Internet and virtual reality [12] , [10]. ITS is more specifically expert systems made to simulate aspects of a human tutor. ITS represent an important class of educational technology poised to play particularly critical role helping learners acquire the skills needed to succeed.

Cognitive tutor contains cognitive model that simulates the student thinking in order to monitor student activities and to provide pedagogical assistance during problem solving. This research does not deal with natural language processing [7], but rather with dialog planning. Studies indicate that experienced human tutors provide the most effective form of instruction known [6]. ITS can offer excellent instruction, but got as good as human tutors [9]. Teaching strategies and tactics should be one of the guiding principles in the development of ITS. This system compared the effectiveness of human tutors and intelligent tutoring system [8].The purpose of this system are learning ITS, studying how to solve problems in computer graphic subject, scientifically explaining one or more of the basic cognitive process and providing more comprehensive instructions to the student by specializing the equation in Computer Graphic subject. Modeling, coaching, and scaffolding are described by cognitive apprenticeship [1], which they claim "help student's acquire an integrated set of skills through processes of observation and guided practice". Modeling, coaching, and scaffolding are described by cognitive apprenticeship [1], which they claim "help student's acquire an integrated set of skills through processes of observation and guided practice".

This paper is organized as follows: section 2 presents the related work concerning with intelligent tutoring systems. A section 3 describes the architecture of the cognitive model. Section 4 explains cognitive model. Section 5 presents cognitive tutoring system design. Section 6 expresses implementation of cognitive tutoring system. Finally, we conclude in section 7.

2. Related Work

The related works concerning with cognitive tutoring system are presented in this section. J.R.Aderson et.l presented cognitive tutors, a particular type of intelligent tutor that supports "guided learning by doing", have been shown to improve cognitive learning in domains like algebra and geometry by approximately one standard deviation over traditional classroom instruction. [9]

A.Cypher described the characteristic of effective demonstrations for machine-learning agents. In this approach, they considered simulated students, which learn a cognitive model by demonstration. The simulated student then generates a set of production rules that because a cognitive model that replicates the demonstration. Because this model is closely related to the model developed by the human student that will use the Cognitive Tutor, call this learning agent a simulated student. [2]

A.Gertner et.l expressed hinting is a general and effective tutoring tactic in one-on-one tutoring when the student has trouble solving a problem or answering a question. In this tutoring setup, the central issue of hinting is to help the student recall the related domain rules or facts that the student may have trouble with. [3]

A.Horrer et.l presented creating cognitive tutor for collaborative learning. In this approach, the first step was to devise a process known as bootstrapping novice data (BND), in which student problem-solving actions are collected and used to being the development of a tutor. Implementation of BND provides a means to directly capture data as a foundation for a collaboration tutor but does not yet fully support tutoring. Next step was to perform two exploratory studies in which dyads of students used their integrated BND software to collaborate in solving modeling tasks. [4]

3. The Architecture of the Cognitive model

"Intelligent Tutoring Systems" (ITS) attempt to simulate such a "teacher", who guides the student's lesson flow, uses pedagogical methods suitable to a student and monitors progress on an individual basis, in an online setup based on his or her level of understanding in the subject. Basically approach is to record the "expertise" of a teacher in the subject and the "understanding" of the student in the subject, so as to deliver an effective personalized "instruction" in an online environment. ITSs typically rely on three types of knowledge, organized into separate modules. They are "Expert Model", "Student Model" and "Instruction Model".

3.1 Expert Model

Expert Model represents the domain knowledge, or expertise possibly derived over years of experience in that particular domain. Generating individual feedback and adapting the instruction content for a student requires detailed as well as structured representation of the subject matter. This is exactly what Expert Model is used for. There are various approaches for recording the domain knowledge and for representing that expertise in an ITS. Some commonly used approaches are black box model, glass box model. Selecting an appropriate approach depends on the domain as well as the needs of the learner.

3.2 Student Model

This model represents the understanding of the student in the subject i.e. what he knows and what he does not know. This information which depicts the student's current knowledge level, is diagnosed by the ITS to adapt the instruction to the student's needs. Gauging the difference between the students and the experts is on of the issues in designing the Student Model. There various models to manage this difference at various levels.

3.3 Instruction Model

An ITS should have three tutoring characteristics:

a) Control over the presentation of the instructional knowledge for selecting and sequencing the subject matter

b) Capabilities for responding to student's questions about instructional goals and content

c) Strategies for determining when a student needs help and for delivering the appropriate help.

The goal of the "Instruction Model", which is also called sometimes called as pedagogical module, is to address these types of issues. Essentially this module consists of teaching strategies and the essential instructions. These strategies must be adapted by this module to suit the student's needs, without the intervention of a human teacher.

Expert model for tutoring system will be a unique test of the sufficiency of cognitive theories. The design of an ITS will contribute to the discovery of more accurate theories of cognition. Cognitive neuroscientists use cognitive models to understand the psychological function of different brain regions. In above model, Human factors researchers use cognitive models to improve human - machine or human - computer interactions.

4. Cognitive model

Cognitive models are appearing in all fields of cognition at a rapidly increasing rate, ranging from perception to memory to problem solving and decision-making. Over 80% of the articles appearing in major theoretical journals of Cognitive Science involve cognitive modeling. Furthermore, applications of cognitive modeling are beginning to spill over into other fields including human factors, clinical psychology, cognitive neuroscience, agent based modeling in economics, and many more. Thus cognitive modeling is becoming an essential tool for Cognitive Science in particular and the Social Sciences in general, and any serious student with an inclination toward theory development needs to become a competent reader and perhaps user of these tools.

Cognitive models are computer program that simulate human performance. A cognitive model is an approximation to animal cognitive processes for the purpose of comprehension and prediction. Cognition is a concept used in different ways by different disciplines, but is generally accept to mean the process of thought. Cognitive science is concerned with understanding the process that the brain, especially the human brain, users to accomplish complex tasks including perceiving, learning, remembering thinking, predicting, inference, problem solving, decision making and planning.

Cognitive models are also different from neural models, although the two can be interrelated. Cognitive models serve to build a bridge between behavior and its neural underpinnings. Cognitive models describe human information processing at a more abstract and mathematical level of analysis. Ideally it is needed to build bridges between the fine grain neural models and the more abstract cognitive models. To some extent, connectionist models strive to achieve this balance by building mathematical models that retain some of the properties of neural models.

4.1 The advantage of cognitive model

The main advantage of cognitive models over conceptual frameworks is that, by using mathematical or computer languages, cognitive models are guaranteed to produce logically valid predictions. This is not true of conclusions based on intuitively based verbal reasoning.

A second important reason for using mathematical or computer models is that they are capable of making precise quantitative predictions. This is not possible solely on the basis of a conceptual or verbal framework. Most researchers would reject a model whose predictions are an order of magnitude off the mark, even though the model makes the correct qualitative or ordinal prediction. Thus it is essential to examine both the qualitative as well as quantitative predictions of a model. Of course, it is always possible to convert a conceptual model into a cognitive model by formalizing the conceptual model (recasting the verbal statements into mathematical or computer language). In fact, this is a common method for developing cognitive models.

Finally, cognitive models provide an abstract level of analysis that makes it computationally feasible to derive precise predictions for complex tasks and multiple measures of behavior (such as choice accuracy, choice response time, and choice confidence), which is often computationally too difficult to do with fine grain neural models. On the other hand, neural models describe the actual neural substrates and neural interconnections that implement these cognitive processes, and so they are better for inferring predictions for bold activation patterns from images or neural activation patterns from multiple cell recording studies.

However, the fine grain level of analysis required to build neural models (involving possibly thousands of neural interconnections) generally make them too difficult to scale up to address complex cognitive tasks.

4.2 Cognitive Tutor

Cognitive Tutors are the most successful ITS today. A cognitive tutor is an intelligent tutoring system which develops a cognitive model of a student as he or she interacts with the program, providing problems and individualized instruction based on this model. The tutorial model is based on the observation of an experienced human tutor.

The interface of the equation-solving section of the cognitive tutor consists of a problem window, skill meter and a message window presents hint message when the student makes an error, the cognitive tutor will immediately “flag” it and, for common errors, output a message in the Help/Error Window that expected to complete are shown in the skill meter.

The tutor also performs knowledge tracing [5]. Those explanations are shown by different dialog [1]. In this model, dialogs appeared in the message window instead of hints. The tutor also uses a real example to illustrate a problem when a student seems to have trouble with variables in that problem [11]. In studying what makes a tutoring session successful identified principles for effective teaching.

One important principle is that tutors should not offer strong hints when students make mistakes. Students miss the opportunity to learn how to solve a problem when tutor gives an answer. The student must respond to the dialog to exit it and return to solving the problem in the problem window.

5. Cognitive Tutoring System Design

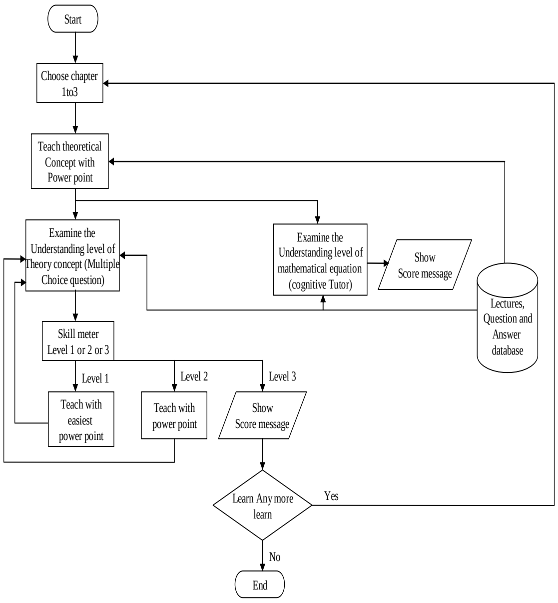

Figure 1. Cognitive Tutoring System Design

Cognitive tutoring system design is presented in this paper. The main purpose of cognitive tutoring system is to examine the understanding level of theory concept by using multiple choice questions and cognitive tutor is to examine the understanding level of mathematic equations. This paper is focused on building a better tutor for the task of solving equations by replacing traditional model-tracing feedback in an ITS with a dialog-based feedback mechanism. This system named “E-tutor “, for Equation Tutor, because it is the first intelligent equation –solving tutor that combines a cognitive model of the domain with a model of dialog-based tutoring.

This system is divided into 2 steps: choose the chapter 1 to 2 and teach theoretical concept with PowerPoint slide and divided into 2 modules. Module one is, to examine the understanding level of theory concept by using multiple choice questions. After module one, skill meter level 1 or 2 or 3. Module two is, to examine the understanding level of mathematical equation with cognitive tutor.

In step (1), students are to learn chapters in Computer Graphic subject. So, students can choose chapter 1 to 3.

In step (2), the system teaches theoretical concept in chapter 1, 2 and 3 with power point slide.

In module one, the system examines the students' understanding level of theory concept by using multiple choice questions. After multiple choice questions are answered in module one, the system differentiate the level of students with skill meter depending on score result. Levels are distinguished as follow: if the result is under 50%, the system teaches students with easy PowerPoint, if the result is between 50% and 60%, the system teaches students with medium PowerPoint slide; if the result is over 60%, teachings are not necessary and show the score.

In module two, the system examines the understanding level of mathematical equation with cognitive tutor. This system examines how to solve the equation step be step, line by line and how learner understands the equations by solving step by step. It shows the hints with error message when error has occurred. So this method makes interactive between learner and computer.

In this system, lectures, questions and answers concerning with theory concept and mathematical equation are stored in database. In teaching theoretical concept with PowerPoint, this system uses by taking out stored lectures in database. The system uses lectures, questions and answers by taking out from in database, to examine the understanding level of theory concept and understanding level of mathematical equation.

6. Implementation

In this paper, cognitive tutoring system is implemented for solving mathematical equations in computer graphic subject. Computer graphic equations included in course number CS-406 specification for U.C.S.Y academy are used for the course materials of this paper. In this paper, the system examines the understanding level of mathematical equation with cognitive tutor. There are many algorithms in Computer Graphic Subject. Among them, seven algorithms are implemented in this paper. They are the Digital Differential Analyzer (DDA) Algorithm, Bresenham’s Line Algorithm, Mid-point Circle Algorithm, and Boundary-Fill 4-Connected Algorithm, Boundary-fill 8-Connected Algorithm, Flood-Fill 4-Connected Algorithm, and Flood-Fill 8-Connected Algorithm. These are implemented by cognitive theory. In this section, the Bresenham’s Line Algorithm is detail explained in theoretical section with PowerPoint.

This system can determine the understanding level of Bresenham’s Line Algorithm. Accurate and efficient raster line-generating algorithms, developed by Bresenham, scan converts lines using only incremental integer calculations that can be adapted to play circles and other curves.

Students initially input the value of pixel’s starting point and end point. So, student inputs x_1=20, y_1=10, x_2=30 and y_2=18. When the student clicks ok button, this system describes a question which student enters the value. After, Δx=10, Δy=8, m=0.8, $2\Delta y$=16, $2\Delta x$ =20 and P_0=6 are calculated, student inputs correct value. If students enter some of the value of Δx, Δy, m,

$2\Delta y$, $2\Delta x$ and P_0 incorrectly, this system shows error message.

Student must choose the correct equation $y_{k+1}=y_k+1$ as P_0 is greater than 0. If the student cannot choose y equation correctly, this system shows error message as shown in Figure 2.

If the student choose $y_{k+1}=y_k$ equation correctly, this system enter P_{k+1} equation $P_{k+1}=P_k+2\Delta x-2\Delta y$ as P_0 is greater than 0. If the student cannot choose P_{k+1} equation correctly, this system shows error message as shown in figure 3.

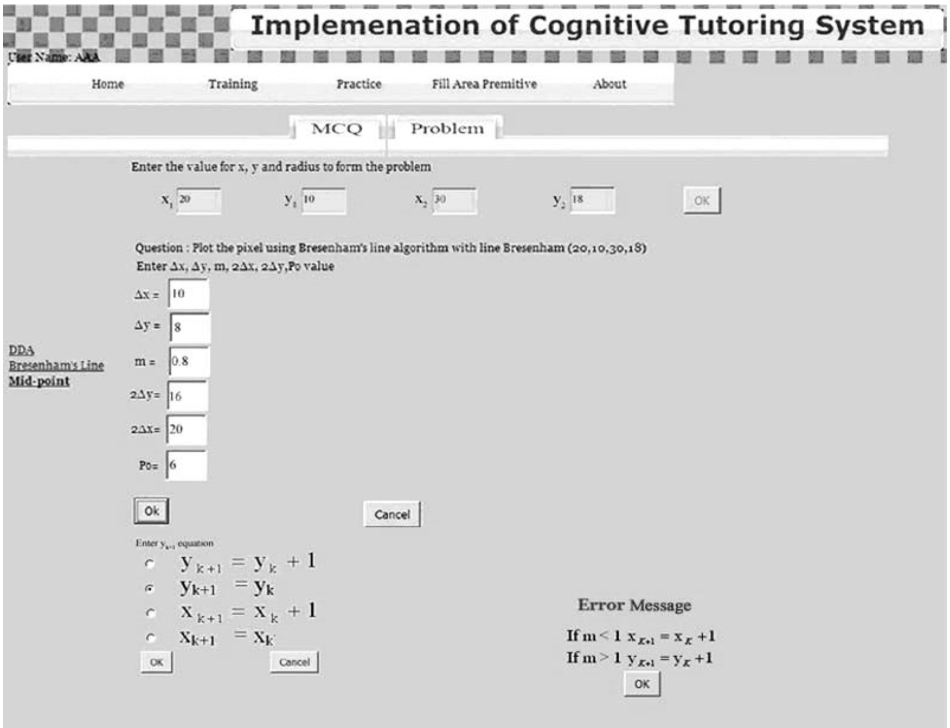

Figure 2. Error Message for Incorrect "y" Equation

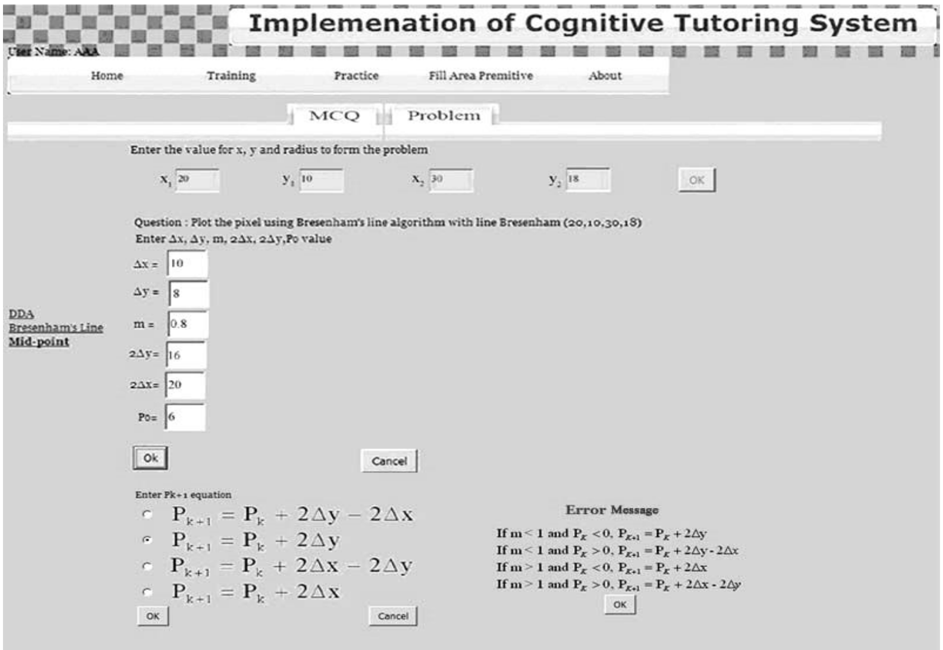

Figure 3. Error Message for Incorrect "P_{k+1}" Equation

Student selects y_{k+1} equation correctly and then selects also P_{k+1} equation correctly. In this case, the system calculates the result step by step. So, the fact that the students notice, by focusing the value of P_{k+1} that the system calculated, and then realize that y_{k+1} and P_{k+1} equation change alternatively. The final statuses of the problems are shown in Figure 4.

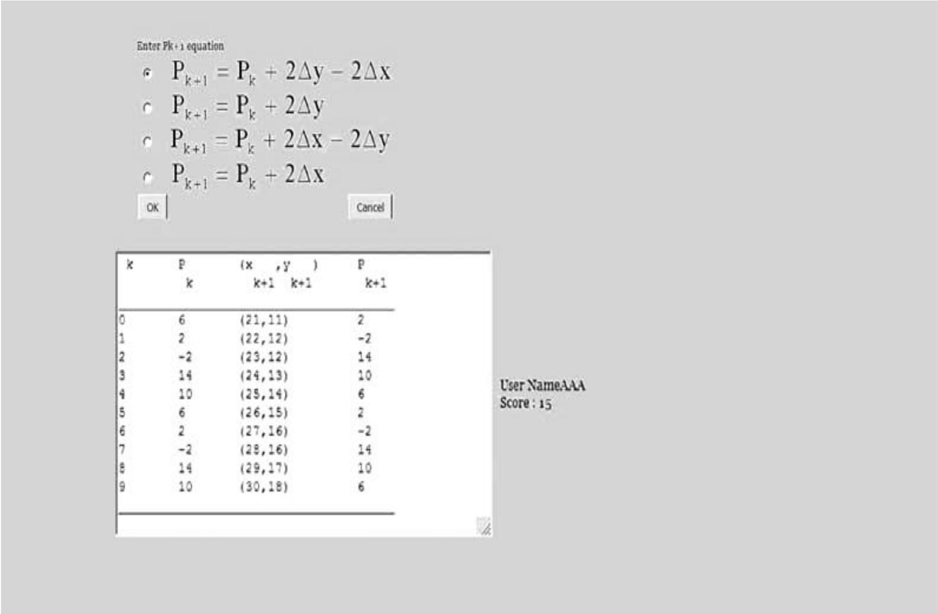

Figure 4. Final Status

7. Conclusion

In this paper we addressed how to systematically deliver pedagogically sound and conversationally content hints in a dialoge-based ITS, Cognitive Tutor. This strategy involved categorizing student answers, and considering both tutoring plan and dialogue history. We then implemented these strategies in a real tutoring system as much as possible. The program was shown to improve student achievement on standardized test items (especially on constructed-responses or performance items), enhance levels of student understanding of mathematical equation in Computer Graphic subject and increase student engagement in the learning process. I believe that effective technologies for learning and doing mathematics should be based on cognitive theory. Since this system is implemented based on cognitive tutor, it is capable of making precise quantitative predictions for the learning in computer graphic subjects.

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