DISTANCE LEARNING BY INTELLIGENT TUTORING SYSTEM
Part II: Student/teacher adaptivity in an Engineering Course

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Abstract: Intelligent Tutoring Systems (ITS) have proven their worth in multiple ways and in multiple domains in Education. In this article the application of an Intelligent Tutoring System to an Engineering Course is introduced. The paper also introduces an explanation of how the course adapts to the students as well as to the teachers. User adaptation is provided by means of the so called pedagogical strategies, which among others specify how to proceed in showing the contents of the matter for a better assimilation of the knowledge by the student. Thus, in this paper the adaptation mechanisms implemented in the ITS, which permit that the students learn better and the professors teach better, are explained in extensive.

1 INTRODUCTION

One of the main problems in Intelligent Tutoring Systems (ITS) consists in adapting to the needs of the user who interacts at each moment. A way to provide user adaptation is by means of the so called pedagogical strategies, which specify how to sequence the contents, what kind of feedback has to be given during education, when and how the tutor's contents (problems, definitions, examples, and so on) have to be shown or explained (Murray, 1999).

ITS have proven their worth in multiple ways and in multiple domains in Education (Anderson, Corbett, Koedinger & Pelletier, 1995; Woolf, Beck, Eliot & Stern, 2001). ITS are growing in acceptance and popularity for several reasons, including: (i) an increased student performance, (ii) a deepened cognitive development, and, (iii) a reduced time for the student to acquire skills and knowledge (Sykes & Franek, 2003). Currently, ITS can be found in core databases, mathematics, physics, language, medicine, and other courses in many schools.

In the field of databases, KERMIT (Suraweera & Mitrovic, 2002) teaches the conceptual modelling of databases using the entity - relation data model; and SQL-Tutor (Mitrovic, Martin & Mayo, 2002) teaches databases SQL language. In both approaches, a model based on restrictions has been used. In the field of physics, Andes (Gertner & VanLehn, 2000) allows the students to solve problems of classic physics in an environment that offers visualization, immediate feedback, and procedural and conceptual help; and Why2-Atlas system (VanLehn et al., 2002) teaches qualitative physics by having students write paragraph-long explanations of simple mechanical phenomena.

In the field of programming languages, ELMART (Weber & Brusilovsky, 2001) teaches programming in LIPS, while JITS (Sykes & Franek, 2003) teaches JAVA, and Bits (Butz, Hua & Maguire, 2004) teaches C++. In the field of mathematics, PAT (Koedinger & Anderson, 1997), Ms. Lindquist (Heffernan & Koedinger, 2002), and Aplusix-Editor (Nicaud, Bouhineau & Huguet, 2002) help the students to learn algebra.

ITS also exist in many other newer but relevant fields. For example, SlideTutor (Crowley & Medvedeva, 2003) is an ITS in dermatopathology, and Design Pattern (Jeremic, Devedzic & Gasevic, 2004) is used to learn design patterns.

On the other hand, there has been a great research effort in learning strategies to be incorporated into ITS (Boulay & Luckin, 2001). As an example, Meyer has used the analogy (Meyer, 2002) to teach a less known domain from a more familiar one. The case based reasoning paradigm has

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also been an inspiration to help in obtaining new incrementing knowledge (Martens, 2004). Even, reinforcement learning has been used (Bennane, 2002). When various strategies are together implemented in an ITS, as for instance in (Prentzas, Hatzilygeroudis & Garofalakis, 2002), the system selects the most appropriate one for the activity that the student is performing.

The structure of the paper is as follows. Section 2 shows the adaptivity mechanisms provided for the student based on the overall e-learning capabilities offered. Section 3 is devoted to the adaptivity to the teacher. Finally some conclusions are provided at the end of the article.

2 STUDENT ADAPTIVITY

2.1 E-learning Capabilities

First of all let us focus on the functionality that the ITS offers to the student (see figure 1).
Of course, the student must register in the course (use case “Register for the course”) as stated in sequence diagram of figure 2. The registered students can change their passwords (through use case “Change password”) each time they enter the course to begin a new study session.

Once a new study session has been started through use case “Enter the course”, the student reads pages of theory (”Read theory”), answers exercises (“Solve exercise”) or test questionnaires (“Solve test”) depending on the task that a pedagogic module proposes through time. While completing an exercise, the student can consult the theory (use case “Consult theory”) closely related to the exercise.

During a study session the student can also change the style of presentation of the matter (that is to say the visual preferences – “Change preferences”). The student may also consult at any time his state after performing any task.

2.2 Student Learning Mechanism

Figure 3 shows the steps followed by the pupil when studying each topic of the course (“Matter learning”).

(1) Firstly, the student has to read the whole theory for the current topic.

(2) Afterwards, the student has to solve the exercises proposed. If the student is a level-1 (low level) student, firstly he has to solve the basic exercises and then the complex ones. O the other side, if the student is a level-2 (high level) student, he will only have to solve the complex exercises. The basic exercises are all shown in a sequential way, and then the ITS evaluates if the student has reached a minimum score associated to the topic. On the contrary, the complex exercises are shown in blocks (composed of a pre-determined quantity of exercises), and, after showing each block, there is an evaluation to ask for a minimum mark before composing the next block. After correctly fulfilling a number of complex exercises, the system goes on to the test questionnaires.

(3) Lastly, the student has to solve the test questionnaire offered.

(4) If there are more topics in the course, the system goes back to step (1). Otherwise, the student has finished studying the matter.

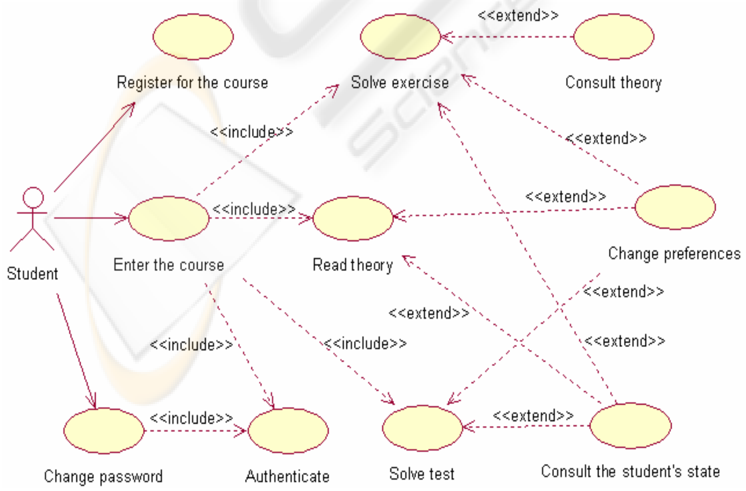

Figure 1: The student’s requirements

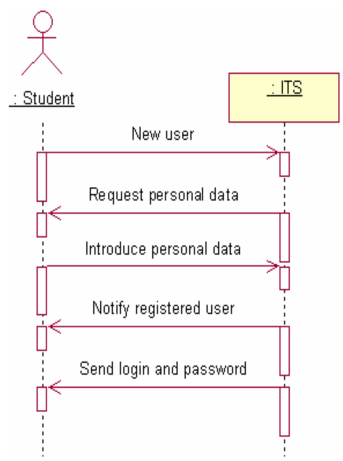

Figure 2: Sequence diagram for use case “Register for the course”

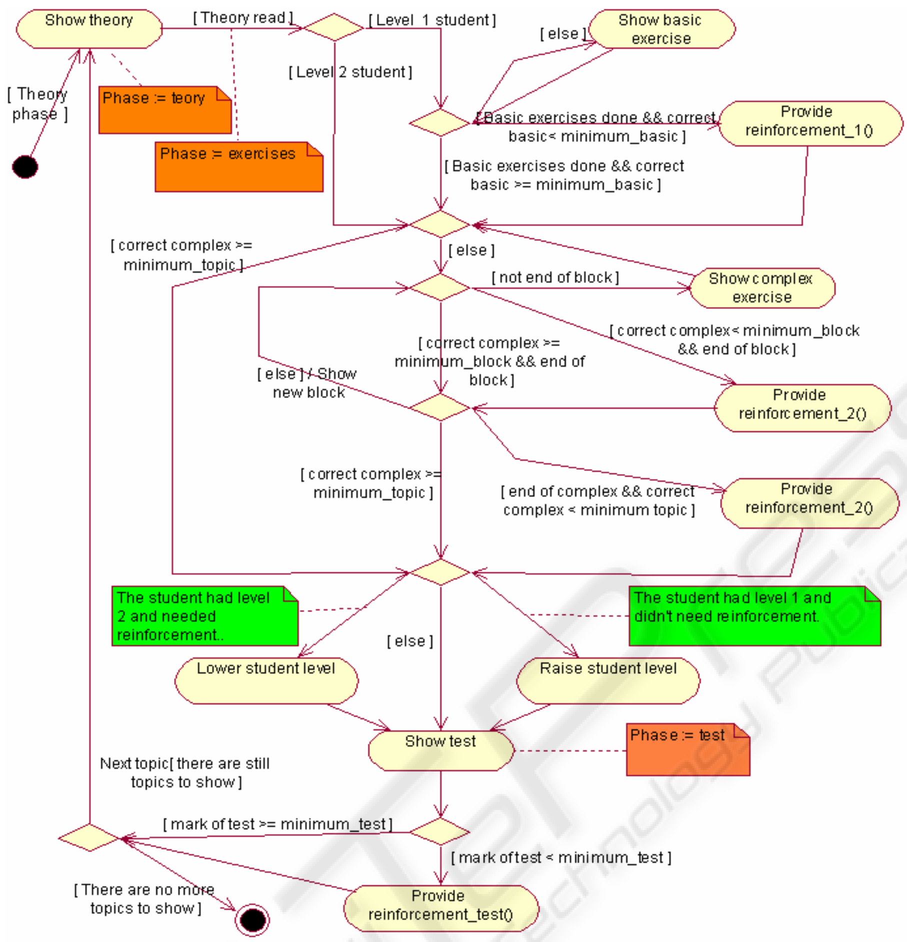

Figure 3: Activity diagram for "Matter learning"

During steps (2) and (3), if the student does not obtain the minimum scores fixed for the topic, he gets reinforcement in order to reach the objectives for the course.

2.2.1 Reinforcement for Basic Exercises

Figure 4 shows how the alumni are reinforced during their activity of solving basic exercises. The system selects one of the exercises previously proposed and not well solved from the set of basic exercises and gets the reinforcement material (based on previous topics studied). This way the system helps the student to correctly solve the exercise.

After proposing the reinforcement material, and before the student has to solve again the basic exercise, the ITS shows the bad response that the student gave previously. When the student passes the minimum score, the system does not go on providing reinforcement. But, and this is the worst situation, if the system has provided reinforcement to all badly answered exercises, and even so the student has not been able to solve them, the ITS tells the student to consult the tutor personally. After having his meeting with the teacher, the student is permitted to advance in the study of the course.

2.2.2 Reinforcement for Complex Exercises

The strategy for providing reinforcement to the student in complex exercises is very similar to the strategy followed to give reinforcement in basic exercises. The only difference is that the ITS firstly tries to reinforce with material of the current topic; and, if the student is still not able to solve the complex exercise, he is reinforced by material from previous topics of the course.

If the student does not have seen all selected complex exercises, he will only get reinforcement for those exercises offered to the user in the last block of complex exercises. But, if he already has been offered all the complex exercises blocks, he will be reinforced for all complex exercises incorrectly solved and not yet reinforced previously.

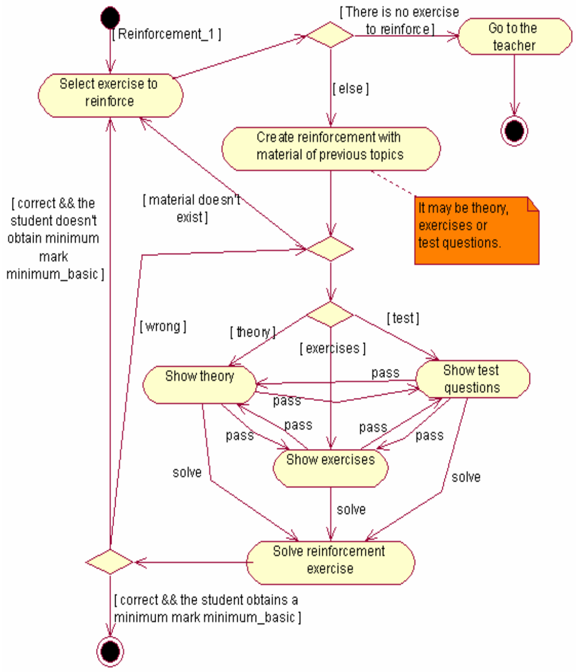

Figure 4: Activity diagram for "Reinforcement for basic exercises"

2.2.3 Reinforcement for Tests

If the student does not get a minimum mark in the test questionnaire proposed for the current topic, the ITS builds a new test questionnaire, offers it to the student, and, if the student does not perform well, the professor personally must reinforce in order to proceed with the learning activity – activity "Go to the teacher" - (see figure 5).

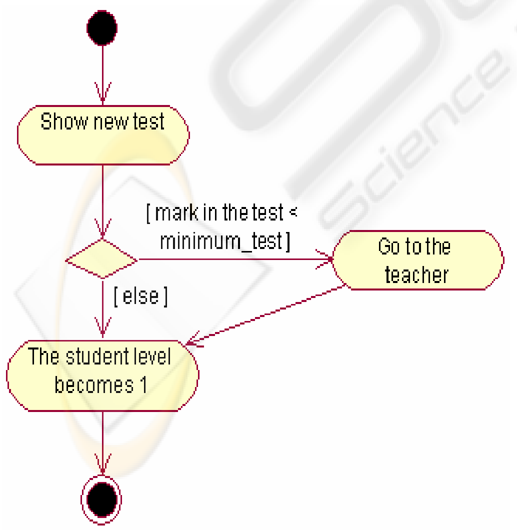

Figure 5: Activity diagram for "Reinforcement for test"

3 TEACHER ADAPTIVITY

3.1 E-teaching Capabilities

Let us also talk about what the teacher can do with the ITS (see figure 6).

Let us firstly focus on the general requirements of the professor. Evidently, the teacher must be authenticated successfully to accede to the ITS functionality (use case "Authenticate"). Once the teacher has been authenticated, he can consult all the didactic material (theory –"Consult theory"-, exercises –"Consult exercises"-, and test questionnaires –"Consult test battery questions") of each of the topics of the matter and obtain quiet statistics fruit of the interaction of the students with the system. It can give reinforcement to the students who need his help, by means of use case "Reinforce the student". This is because the student has not managed to advance in the study of the subject because the material that has provided to him the pedagogic module is not sufficient to overcome the goals of the topic that he is studying. The teacher may change the style of presentation (colours, margins, interlineate, size and type of source) of the interface.

But, the biggest benefit is that the teacher may consult statistics fruit of the interaction of the students with the system. For every topic of the matter, the teacher also obtains the number of times there has been a need to reinforce the students to be able to advance in the study.

The information provided to the teacher is gathered during interaction of the students with the ITS. Respect to the theory read by the students, the teacher can know the number of times that the students have acceded to every page of theory and the average time that they have spent in every visit. The system also records when students have done scroll when they visit a page of theory and it may reproduce all movements performed. In the same sense, and in accordance with the exercises proposed to the students, the teacher is able to know the average time that students have spent in performing them, the percentage of pupils that have not been able to perform them correctly, and how many students have answered well or badly. The teacher can also know the number of times that every exercise has had to be explained again by means of theory pages. Lastly, for the case of test questionnaires, the teacher can know the number of times that every test question has been shown to the students, the percentage of tests answered well or badly, and so on.

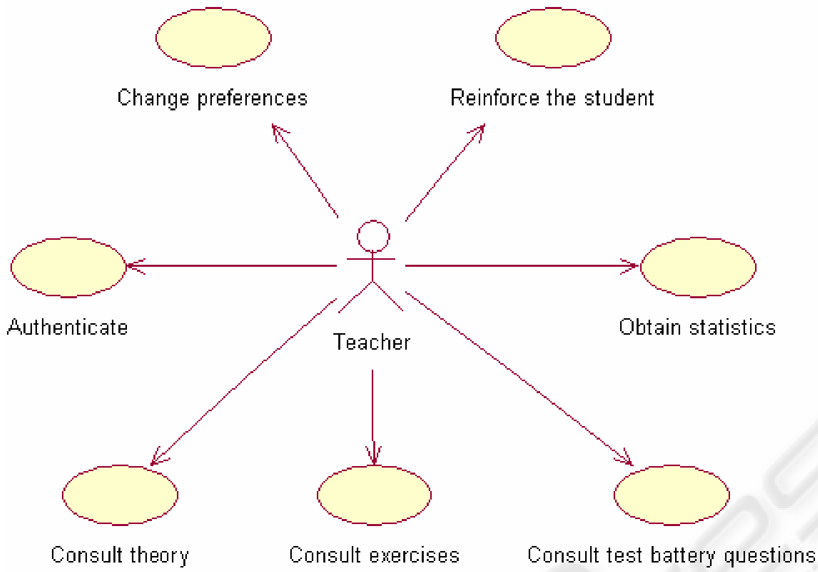

Figure 6: The professor’s capabilities

3.2 Teacher Learning Mechanism

The teacher may learn how to enhance teaching of the course from the statistics gotten from the interaction of the students with the ITS.

The teacher will be able to know the efficiency of the implemented mechanism to reinforce the students. For each topic of the course, the teacher may consult the information on the number of times that the students have needed reinforcement and how many times the students have personally been reinforced by the professor. Moreover, the teacher may consult statistics of information gathered during theory, exercises and test phases, respectively.

The teacher may know the number of times that the students have accessed each theory page and the mean time the students have been on each visited page. The statistics are classified as (a) pages read during the theory phase, (b) pages consulted during the exercises phase, either solicited by the student or due to the reinforcement mechanism. The ITS also offers the possibility to know which students have performed scrolling when visiting theory pages and to reproduce the scroll movements as performed.

In relation to the exercises statistics, the professor may consult to how many students an exercise has been shown, the mean time the students have spent to solve the exercise and the percentage of blank, correct and incorrect answers to the exercise. There is a classification in exercises presented as reinforcement and normal exercises. The information on how many times an exercise has been explained personally by the teacher is also provided.

In relation to test questionnaires, the teacher may look for the number of times that each test question has been presented to the students and the number of times that the students have left the test blank, have answered correctly and have answered incorrectly. It is possible to know if the test question was presented as reinforcement to an exercise, or if it was part of a test questionnaire. Furthermore, the teacher may know the number of times that he had to personally explain the test question.

4 CONCLUSIONS

The ITS have turned into a technology of increasing interest to complement traditional education so much from the perspective of the students as from that of the teachers. In this article the application of an ITS architecture to an engineering course has been introduced. The aim of the ITS is that the students can learn more and better, and on the other hand that the teachers can extract conclusions that help them to improve their teaching activities.

In this paper, we have introduced an explanation of how the course adapts to the students as well as to the teachers. User adaptation is provided by means of the so called pedagogical strategies, which among others specify how to proceed in showing the contents of the matter for a better assimilation of the knowledge by the student.

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