World Journal on Educational Technology

2 (2009) 89-97

www.world-education-center.org/index.php/wjet

Intelligent tutorial system for teaching of probability and statistics at high school in Mexico

Fernando Gudino-Penaloza [a], Miguel Gonzalez Mendoza [a], Neil Hernandez Gress [a], Jaime Mora Vargas [a] *

[a] Professors of the Tecnológico de Monterrey, Campus Estado de México, Mexico

Received May 13, 2009; revised July 25, 2009; accepted October 21 , 2009

Abstract

This paper describes the implementation of an intelligent tutoring system dedicated to teaching probability and statistics at the preparatory school (or high school) in Mexico. The system solution was used as a desktop computer and adapted to carry a mobile environment for the implementation of mobile learning or m-learning. The system complies with the idea of being adaptable to the needs of each student and is able to adapt to three different teaching models that meet the criteria of three student profiles.

Keywords: m-learning; preparatory school; statistics and probability ITS; ENLACE exam; TUPROESA

1. INTRODUCTION

Intelligent tutoring systems (ITS) are computer-based systems that have instructional models that define what, when and how to teach certain knowledge. The idea of using computerized systems for education is not new, since the sixties systems were established aimed at helping users improve their skills in a subject (Helander, Landauer & Prabhu, 1997). In the seventies it was decided that to achieve real learning experience, it had to simulate the behavior of real tutors, which would lead to understanding such systems. Thus intelligent tutoring systems were created, which are tailored to

* Tel.: +52 55 5865 5690; fax: +55 55 5865 5751
E-mail address: {A01160720, mgonza, ngress, jmora}@itesm.mx

the educational needs and personal preferences of individual students, not forsaking the speed of system response. Moreover, with the continuous advance of computer technology, especially Internet and mobile technologies, the teaching field has adapted to this development in order to improve the teaching process. It is in the field of mobile devices a tool is developed which aids the upper middle level students to improve their performance in the course of Probability and Statistics with the use of m-learning application known to TUPROESA. The area of mathematics was decided because they are considered an indispensable tool, not just on an academic level but on the development of modern human life. The deplorable results of the Mexican National Examination called ENLACE since 2007, show a gap in the development of mathematical abilities and is the main reason of this work (ENLACE, 2009).

2. METHODS

2.1. Intelligent tutoring systems

The goal of ITS is to provide the benefits of one-on-one instruction automatically and cost effectively. Just as in training simulations, ITS enable participants to practice their skills by carrying out tasks within highly interactive learning environments. However, ITS goes beyond training simulations by answering user questions and providing individualized guidance. Unlike other computer-based training technologies, ITS systems assess each learner's actions within these interactive environments and develop a model of their knowledge, skills, and expertise. Based on the learner model, ITS s tailor instructional strategies, in terms of both the content and style, and provide explanations, hints, examples, demonstrations, and practice problems as needed.

Many traditional instructional methods present learners with facts and concepts followed by test questions. These methods are effective in exposing people to large amounts of information and testing their recall. However, they often instill "inert knowledge" that learners can recall but may not apply correctly when needed. By contrast, ITS systems use simulations and other highly interactive learning environments that require people to apply their knowledge and skills. These active, situated learning environments help them retain and apply knowledge and skills more effectively in operational settings.

An ITS has four components: domain model, student model, pedagogical model and the user interface, with variations according to the relative level of intelligence of each of the components. The term smart refers to the fact that the system has to determine: what, when, and how to teach certain knowledge, as would a mentor in real life.

2.2. Domain Model

The method used to model the domain is the concept maps (Jonassen et al., 1997), which has more flexible and re-usable features. This method uses directed graphs, where nodes represent the knowledge you want to teach, and the arcs represent the relationships between them (pre-requisite, element of, it is) and a manager for the creation of examples and exercises. Block sets are created for each element of the topic (node), where each block defines a step in solving the problem, and these blocks are given a weight between 0 and 1 (being the total sum equal to one) by volume step in solving the problem. Each block can be assigned an exception that indicates whether the procedure has other alternative solutions. So the final composites obtained a primary solution and one or more alternative solutions.

Figure 1 shows the Concept map for TUPROESA ; each node; represented by circles in the figure; represents knowledge and each arc; the arrows; represents relationship between topics. The rectangular shape in the right side represents the process to solve an exercise and the respective exceptions in the proccess.

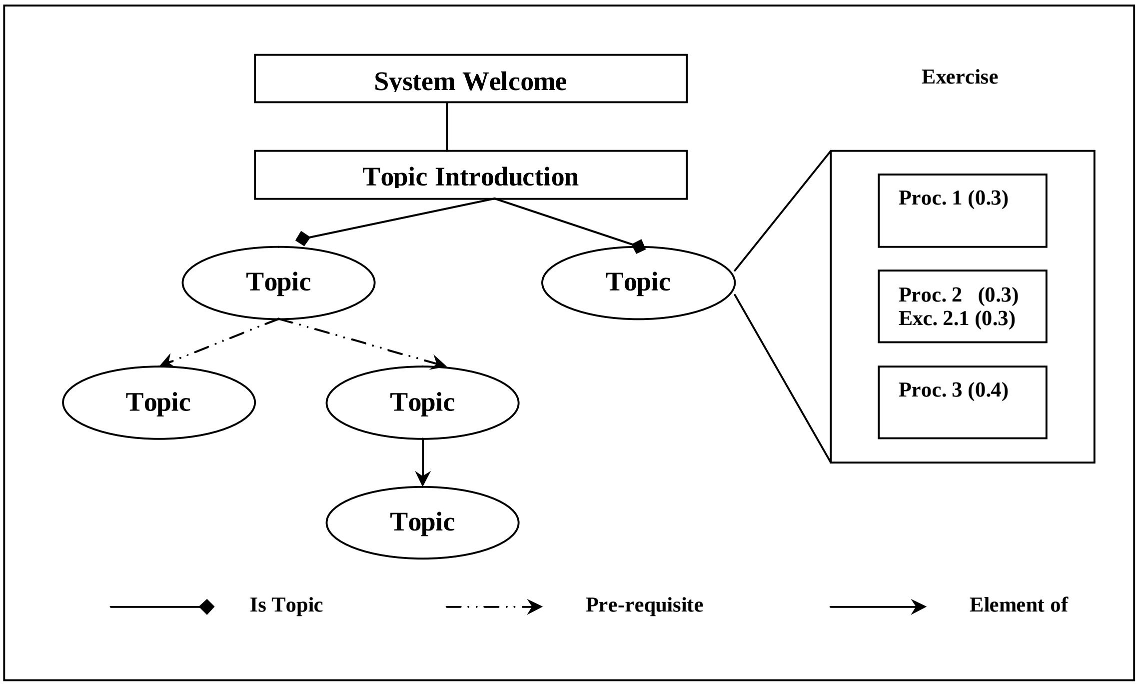

Figure 1. *The Concept map for TUPROESA.*

2.3. Student Model

The student model is a description of the characteristics of learning activities for students (Amershi & Conati, 2007). Accurate model is required to define the strategy in teaching, and it must contain a customization of the student. For our case we have proposed a prototype model based on the Grasha- Riechmann model (Grasha & Riechmann, 1975).

The model characterizes the student based on three areas: student profile, user behavior and overall performance. The first aspect refers to data and preferences of the student: age, sex, etc., the latter measured using the system, the third measures student performance. In this way, students are classified in three prototypes: dependent / participatory / competitive (A); dependent / participatory (B) independent / participatory (C). To determine the type of student, the system uses clustering algorithms (Amershi & Conati, 2007).

2.4. Pedagogical Model

Similarly as the students prototypes, a set of teaching prototypes were created, based on the instructional process used to transmit the content and profile of students. We created three prototypes of teaching: Expert (E), Delegate (D) and Personal (P) (Grasha & Riechmann, 1975). These components were adapted to the student prototypes, as shown in Table 1.

Table 1. *Correspondence matrix. Tutor prototypes and student profilee*

Tutor Prototype	Student A	Student B	Student C
E	Yes	No	No
D	No	Yes	No
P	No	No	Yes

2.5. User Model

The user interface is an element which should be given importance (Murray, 1999), this interface should not be complicated to use and must be as intuitive as possible. In our case TUPROESA is based on two models of interface, the first version is developed for and deployed in personal computers PC, while the second was developed as an extension targeted at mobile devices in their design of m-learning. The PC version is a full version of multimedia content (video, audio, interactive presentations, etc.). The mobile version makes use of Web resources (podcast).

Figure 2 shows the User Interface for TUPROESA, in the left side the personal computer version, this consumes a large amount of computational resources, in part because it contains graphic content,as is an animated tutor. In the center and right side the mobile version is shown, content for this version has been developed based on podcast and web contended for mobile devices, instead of adapting the content of the PC version

Figure 2. *User Interface*

2.6. TUPROESA

Progress in the development of mobile technologies makes the idea of carrying educational systems to these devices more attractive (Thomas, 2005). However, the application of these systems has some restrictions due to limited capabilities of devices (battery life, processor capabilities and memory, small screens and tiny keyboard). However, the size, portability, and communication capabilities of these devices provide new opportunities to deliver educational services to users.

The challenges in this field require a technology that facilitates the construction of more dynamic, intelligent and flexible educational applications. Currently, m-learning studies have focused on adapting existing systems, devices (Smith, 2007; CITE, 2009). Although these systems provide support for users and allow them to learn, content standards are based on systems that do not take into account the needs that each student requires.

2.7. Multi-Agent System

In this work we selected a multi-agent system server-client architecture for the implementation of the tutorial, as shown in Figure 3. The server side is responsible for the tutorial management and the device side is focused on developing the user interface.

The system is based on two groups of agents, resident agents, located in the mobile and external agents on the server side. The resident agents display the content (interface agents or IA) and are responsible for monitoring the performance of the user in reference to the use that this gives the system, measuring the time each student uses the program, the time it takes to advance into the content, interaction areas within the interface, etc. (Monitoring Agents, MA). These data are stored in the session and then sent to Pedagogical manager in the server , which determines the best set of files to be sent to the device and how they should used the next time the user uses the system. Meanwhile external agents fulfill the duties of a intelligent tutoring system; they are agents specialized in knowledge management called Domain Agents or DA; agents for student modeling (progress, preferences, mistakes.) called Student Agents or SA and agents responsible for defining the pedagogical model to use called Pedagogical Agents or PA, the latter type of agents are responsible for negotiating between the DA and SA agents to deliver the best content possible.

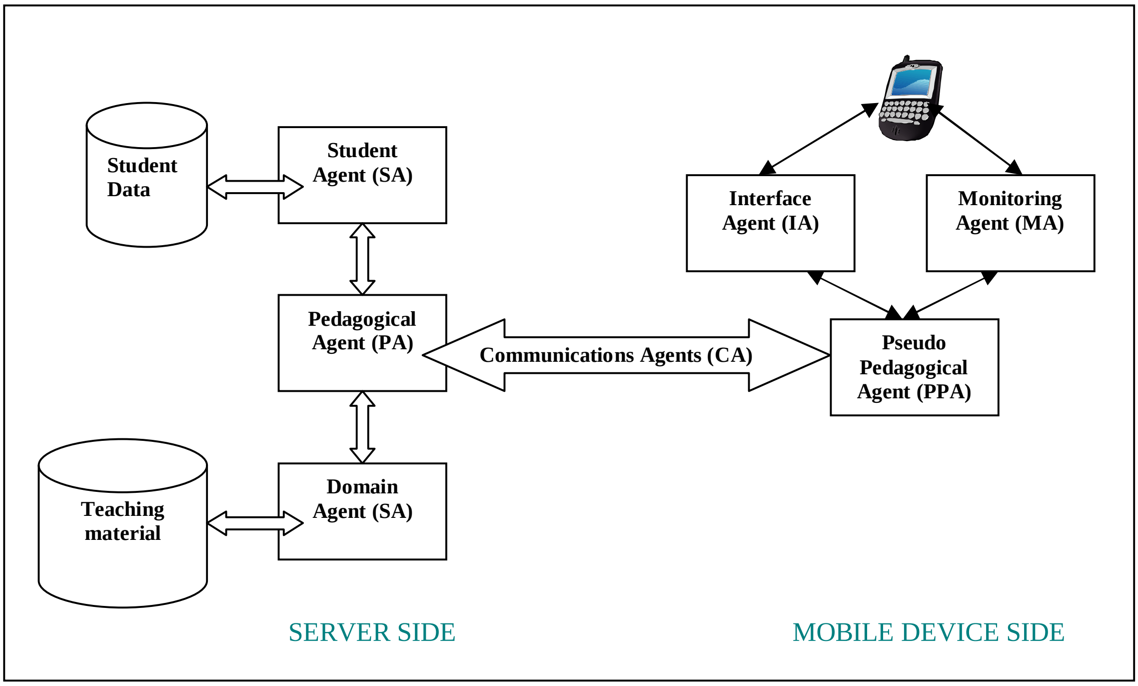

Figure 3. *Multi-agent architecture for mobile devices based on the IEEE 1484 LTSA*

They are another two types of agents, the Communications Agents or CA and the Pseudo Pedagogical agents or PPA. The Communications agents are responsible for allowing communication between agents both server side and the mobile device side, and they determinate the information's flows and continuously checks whether the agents on both sides need to communicate with another agent on the opposite side. Meanwhile the Pseudo pedagogical agent PPA is a reduced version of the pedagogical agent PA, by reduced we refer to the fact that not all properties of the server-side agents are develop by this agent (e.g., is not a negotiator between agents SA and DA); but it has other qualities of the pedagogical agent, for example it can take the decision to redefine the order in which content must show, in function to the data that the monitoring agent MA has gathered in the development of the session.

In the initial session, the agent is responsible for conducting a test of the student's skill level, this in order to initialize the system and add a customization from the start of the course. The data collected is sent to the Pedagogical agent, this redirects the information to the Student agent and designs the first working session with the content that it considers best. Moreover the student's profile is updated and the profile that best meets is sent in response to pedagogical agents. The domain agents start creating a database with the contents that are required by the PA agent and sent. Finally the first session is created and sent to the mobile device, ceding control to the resident agents.

Before the end of the session, data is sent to the Pedagogical agent, which redirects it, and again it makes decisions that are communicated to the other agents in the server. Pedagogical Agent creates the following sessions and only makes adjustments, according to new data received. If the received data show a great similarity changes will be small. Otherwise, if the changes are very drastic, the system does not try to make changes in the same way, the changes will be done in progressive stages. The Pedagogical agent believes that a sudden change does not represent the actual behavior of the user, instead, considers this as an anomaly. If the condition persists and the behavior is real, a gradual shift decreases the level of frustration that users experiment when they have to learn to use the system again.

At the beginning of each session, the pedagogical agent sends the contents through the agents of communication, with instructions on how and when deployed, and also sends the feedback system (which makes the experience of using the tutorial a little more pleasant). The Pseudo Pedagogical agent receives the data and redirects to interface agents, in addition alerts the Monitoring Agents, of which aspects need to be monitored (this reduces the amount of resources that these agents need while they put emphasis on those items required by the PPA and PA agents and not constantly monitor all the performance) However, periodically such agents were sampled throughout the performance, in order not to leave out some aspect that could be important for the student and that its routine monitoring had been omitted.

3. RESULTS AND DISCUSSION

In order to study and analyze system performance, a series of tests for a module of the course was equivalent to six class sessions in three weeks. We used the system in two upper secondary education institutions, one public and one private school. The study was composed by 61 women and 48 men from both institutions. Students have previous knowledge of mathematics: algebra, arithmetic and geometry, and computer products.

Two types of tests were made: We analyzed the level of acceptance of the system and measured the performance of students in an examination. It divided the population into three groups randomly: students who took the class in a traditional way (without the tutor) called Group A. Students who take classes and use the tutor as an aid in learning (group B) and finally , students use their class time to learn with the tutorial (group C).

Referring to system acceptance level yielded the following data: 68% were attracted to the idea of the tutorial, 61% agree that the user interface is intuitive, 73% liked the content (videos, audio, etc.) and 13% agreed that they prefer the tutorial to their teacher. From statistical analysis of the data we note the following: the student model mentioned most frequently in the experiment is: A participatory / dependent with 68%, the model (B) showed 23% while the prototype C alone was 9%.

Referring to the review conducted, the results are shown in Table 2. From them we observe that the group, group C had a drop in grades, while group A showed a similar pattern to that shown during the course, finally the group B increased their performance significantly.

Table 2. Results of performance shown by the different students prototypes in the assessment test. Results are shown in percentage

Group	Grades Dropping	Mainteined their average	Improved their skills
A	11	83,5	5,5
B	2	43	55
c	61	28	11

4. CONCLUSION

The use of computer systems as teaching tools is popular nowadays. These tools achieve even simulate the behavior of the tutors to add artificial intelligence to the system bringing the development of intelligent tutoring; they have been able to adapt to the needs of each student, as serious in real life. However, the great variety of changes and strategies that a human tutor can perform immediately, have not yet been able to simulate correctly. The idea is to create systems that seek to assist, rather than replace human tutors in developing skills of students. These new technologies like Internet and mobile devices, make the development of these tools head towards that direction, in what is known as m-learning. Although their development is still precarious, it seems that is the new field of education.

REFERENCES

Amershi, S., and Conati, C. (2007). *Unsupervised and Supervised Machine Learning in User Modeling for Intelligent Learning Environments.* In: 12th international Conference on Intelligent User Interfaces, pp. 72-81. ACM Press, New York.

Centro para la Innovación en Tecnología y Educación CITE, Retrieved October 03 , 2008 from http://prod49ws.itesm.mx/images/publicaciones/aprendizaje movil.pdf

Grasha, A., and Riechmann, S. (1975). *Student Learning Styles Questionnaire*. University of Cincinnati Faculty Resource C.

Helander, M., Landauer, T., and Prabhu, P. (Ed.). (1997*). Intelligent Tutoring Systems Handbook of Human-Computer Interaction*, 2d. Completely Revised Edition in. Elsevier S. B.V.

Jonassen, D., Reeves, T., Hong, N.,et al. (1997). *Concept Mapping as Cognitive Learning and Assessment Tools*. J. Interactive Learning Res., 8, 289-308.

Mimosa Wireless –"*Bringing Intelligence to a Device near You"*, Retrieved 02 February, 2009 from http://www.mimosa-wireless.co.uk/other-applications.htm

Murray, T. (1999) *Authoring Intelligent Tutoring Systems: An analysis of the state of the art*. J. A I in Education, 10, 98—29.

Prueba ENLACE, Retrieved 12 June, 2009 from http://enlace.sep.gob.mx/enlacems.html

Smith, S. (2007). Mobile Learning. Association for Learning Technology Issue 7 January.
Thomas, M. (2005). *E-learning on the move*. Retrieved 19 September, 2009 from http://www.guardian.co.uk/education/2005/may/23/elearning.highereducation