Intelligent Learning System Based on SCORM Learning Objects

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Abstract. This paper shows the creation of the adaptive SCORM sequencing models, taking advantage of the latest developments offered by the artificial intelligence field, to provide the best choice to the student, based in learning objects, using a tutor model in self learning. The Tutor uses decision networks also called influence diagrams, to improve the development of resources and learning materials in a learning content management system, to offer students the best pedagogical decision according to their performance. The intelligent learning system is validated in an online environment. The results of the evaluation process in undergraduate engineering courses are encouraging because they show improvements in student's learning who used this approach, compared to those who did not use it. The paper also shows the potential application of this learning approach for power system's operators.

Keywords: adaptive learning, learning objects, tutor model, tutorial systems.

1 Introduction

The use of technology in learning helps to create a situation learner-centered education that promotes self learning and development of their critical and creative thinking. E-Learning environment is the use of Internet technologies that provide a wide range of solutions for knowledge [1]. E-Learning systems facilitate learning without constraints of time and space, characteristics that affect any organization to extend the option of learning to a greater number of workers and enter new training models. Learning objects (LOs) are emerging, as an effort to create educational components or modules that can be reused in different learning contexts. In education and business training, the use of e-Learning platforms and the design of online courses to their own educational technologies have increased significantly. The use of LOs in e-Learning platform has allowed us to give knowledge, provide information and guide learning activities in the materials.

The Sharable Content Object Reference Model (SCORM) is the standard for e-Learning more used in the world for the development of courses made up of

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independent units of information residing in a repository and can be seen on any platform that is also compliant with this standard [2]. The usage and effectiveness of learning using SCORM is the purpose of this work, because you can define different paths for a student to learn also called sequencing models) and we solve as well the space and time situation in a safe training environment based on a reliable tool. The modeling adaptive sequence SCORM proposed in this work), enables the tutor or instructor to add complexity to the models of sequence or different paths of learning resources in less time and promotes improvements in the student's learning with the use of these models.

2 SCORM Sequencing

SCORM sequencing provides the necessary tools to developers of E-learning Courses so they can be able to create complex designs that can adapt it selves to student's individual learning needs, consistently applied in sequencing capabilities that offer the following models [3]:

1. Tracking or monitoring model: the values of this model are used to control the behavior sequence. For every learning attempt made for a student in a certain activity, it will have data on the status of the activity associated with it.
2. Sequencing definition model: sequence uses a model based on rules. One activity can apply a set of zero or more sequencing rules and these are evaluated at specific times during the various sequencing behaviors.
3. Execution model: it is used by LOs to communicate information about a student's interaction) with that content object (for example state or grades).

SCORM neither considers nor excludes the artificial intelligence-based sequencing, its use in contexts involving other intelligent agents is not prohibited either. However, it does not define the roles of these other agents or sequencing behaviors that arise as a result of the involvement of such agents. The navigation model provides flexibility for SCORM content developers to provide navigation controls to determine whether the student will have the option or not to navigate freely in the course content. However, this can also be a disadvantage by not being clear about the rules of navigation for SCORM content developers.

3 Intelligent Tutoring Systems

Intelligent Tutoring Systems (ITS) are interactive learning environments that have the ability to adapt them selves to a specific student during the teaching process [4]. In general, the adaptation process can be described by three phases: (i) getting the information about the student, (ii) processing the information to initialize and update a student's model), and (iii) using the student's model to provide the adaptation.

An ITS is a system that has as main objective to reproduce the behavior of a human tutor that can adapt it self to the rhythm of student's learning [5]. According to

[6] the four main components of an ITS are the student´s model, pedagogical model, the knowledge domain model and communication model. Unlike Woolf, other authors such as [7] proposed as the fifth component the expert model, which was previously thought to be within the knowledge domain model.

4 Sequencing and Navigation in ITS

These ITSs did not emerge to be used in the Web; however the potential of the Web in distance learning has led to the implementation of projects and studies to develop ITSs based on that platform. According to [8], one of the techniques more relevant to achieve this, is the use of intelligent sequence of knowledge, involving the adaptive selection of the following item to learn, using the student's model and knowledge about the learning material. The sequence of the courses is a well established technology in the field of ITSs that creates a course individualized for each student, selecting dynamically the optimal operation of instruction (presentation, example, question or problem) at any time.

For their simplicity and effectiveness the techniques of Artificial Intelligence used predominantly in ITS to create the student's model are the Bayesian network and the decision networks or influence diagrams, both classified in Probabilistic Graphical Models (PGMs). According to Koller, the PGMs modelate the uncertainty with probabilistic variables related by dependencies that are expressed in the form of acyclic graphical elements [9].

4.1 Using Probabilistic Graphical Models for Adaptive Sequence

As mentioned above, the sequencing of LOs in SCORM is a rule's-based model, where the instructor plays a key role in establishing previously the different ways of learning that a student can take. This does not guarantee the effectiveness of learning, by not considering all the possible paths of learning and adaptation for specific learning needs of each student, as a solution for this problem, is suggested in this work the use of the MGPs tools to add intelligence and adaptation to existing SCORM sequencing model. The MGPs (Koller, Friedman, Getoor, and Taskar 2007) in Artificial Intelligence are a powerful mechanism for adaptation to the needs of a student's learning. From the set of techniques that provide this type of models the ones proposed in this work to be used are the decision networks (also called influence diagrams). In its most general form a decision network represents information about the current state of the tutor, possible actions, the state that will result from the action of the tutor and the usefulness of the resulting state (Russell and Norvig 2008). Combining utility theory with probability theory allows a tutor to select actions that maximize their expected performance.

4.2 Using Decision Networks in the Sequencing and Navigation of Los

Decision networks are a simple formalism to express and solve decision problems and therefore there is a direct application to the problem of sequence of LOs, where the result of the propagation of the evidences in this network would provide the best pedagogical action followed by the student, in other words the sequence of LOs suitable for each student. Being also the decision networks an extension of Bayesian networks is still inferring and diagnosing the current cognitive state of the student, making possible the sequencing and adaptive navigation. However, to actually achieve an adaptive learning situation, must be taken into consideration students' prior knowledge in LO and propagate that evidence with the current cognitive state. This can be achieved considering the “time factor” to create a dynamic decision network.

5 Intelligent Learning System Based on Learning Objects

The model proposed in this work has been called Intelligent Learning System or SI-APRENDE. This system provides the Tutor Model of an ITS to establish an adaptive sequence and navigation of LOs. They were used dynamic decision networks to select the pedagogical action that best suits the situation of each student's learning; one of the main advantages of decision networks is precisely the combination of the theories of probability, utility and decision.

The decision network used in SI-APRENDE manages the uncertainty associated with the status of a student's knowledge of LO by the conditional probabilities that the expert should initially provide. The ability of inference which has a decision network is another of its advantages. It has observable variables resulting from the student's interaction with the system, such as the progress of the activity or the satisfaction of the objective and can also makes predictions based on evidence of knowledge of LO. The utility function provided by the application domain expert ensures that the Tutor Model makes the best decision.

5.1 General Architecture of the System

The architecture of the intelligent learning system SI-APRENDE is designed in three layers: presentation, logic and data. Each one is described below and is represented in (Fig. 1):

a) Presentation Layer: contains the graphical interface that connects the system with the user in a Web environment. This user interface uses AJAX components that facilitate its development in .NET platform, as well as a simple and friendly interaction with the user.

b) Business Logic Layer: referring to the business rules and validations required in the application, such as educational activities of the tutor model and monitoring of learning activities related to knowledge, skills, goal achievement, activity's satisfaction and progress. In this layer other components are associated with other components such as: user management, monitoring of learning activities, sequencing and navigation, which are inherent components of the same application SI-APRENDE; PGMs such as Elvira, Carmen or any other application that can create nodes and relationships and make inferences and propagation with evidence; tagger Software of LOs, i.e. any environment or application that allows creating labels and SCORM packages.

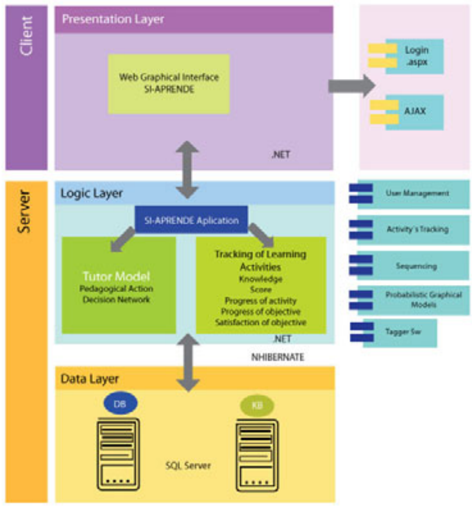

Fig. 1. Architecture of Adaptive Intelligent Environment SI-APRENDE

c) Data Layer, easy access and manipulation of information stored in databases. The technology to use is: Hibernate .NET (NHibernate). Specifically, it contains access to the repository of SCORM learning objects database and SI-APRENDE system. Manager is proposed as a relational database to Microsoft SQL Server.

5.2 Domain Knowledge Model

The domain knowledge model has a structure where a course has different topics, each topic in turn has various subtopics and each subtopic is made up of one or more LOs containing the concept or knowledge units required for this item. In this way the generic base can be applied in any domain of course's application.

5.3 Tutor Module

An important aspect of the tutor model, also known as instructional or educational model, is the sequence of the learning material presented to each student. We present in this paper a tutor model with a decision network that selects the best pedagogical action for each student.

This decision network consisted of the following random variables (see Fig. 2): knowledge of LO, satisfaction of the objective, progress of the objective, progress of the activity, score of LO, quiz, project, task and practice. KwLO random node has four values: Very Good, Good, Enough and Not Enough. The decision node considers the pedagogical actions that will be evaluated according to the utility function to select the best one, but have identified four possible pedagogical actions have been identified: LO challenge, Next LO, Repeat refined and Repetition of LO.

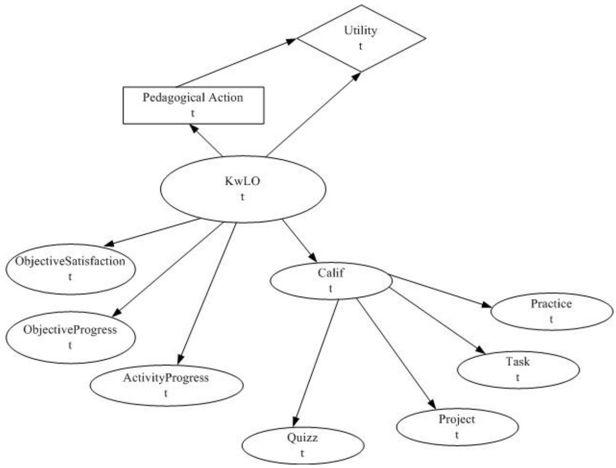

Fig. 2. Decision Network

The calibration of the decision network is given by experts in the domain. The utility's table entries are based on the teacher's experience according to the best over all possible pedagogical actions according to the given knowledge state and student's interaction.

The Fig. 3 shows the same decision network described in the previous figure now considering the evidence of LO´s Knowledge random node in the previous time as well as pedagogical action selected from the previous time, making it a dynamic decision network.

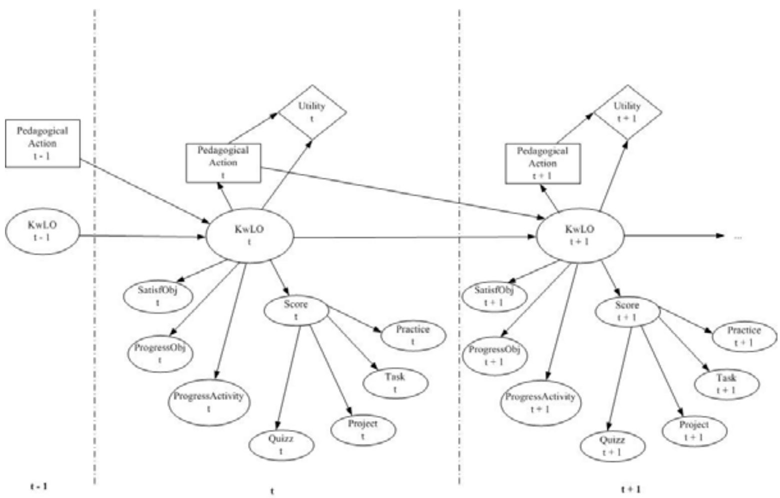

Fig. 3. Dynamic Decision Network

This dynamic model allows the user to take the accumulated evidence from previous experiments with the results of the current knowledge object. The aim is to update the knowledge objects and take the best pedagogic action.

6 Case Study

It was chosen as case study the model's application to undergraduate courses such as Mathematics II, Electricity and Magnetism, and Introduction to Physics. The instructors designed four LOs of a specific topic for each course, which were integrated with the standard SCORM technique to leave them available in the SI-APRENDE. It was planned that all students started at the same LO of their respective courses. The following actions were designed to achieve pedagogical adaptation to the learning needs of each student:

- LO's challenge or higher difficulty level: when the student gets a good grade (or its numeric equivalent 9 <= 10 on a scale of 1 to 10).
- Next LO with the same difficulty level as the previous one: when the student gets a grade in the following range 7 <= 9 on a scale of 1 to 10.
- Refined repetition or lower difficulty level, when the student scores sufficiently (or its numeric equivalent 6 <= 7 on a scale of 1 to 10).
- LO's repetition, when the student scores noncredit able (or its numeric equivalent 1 <= 6 on a scale of 1 to 10).

This set of pedagogical actions that were based only in the score, was initially defined by the instructors. However, adaptive navigation in a SCORM environment is more complex than that, the pedagogical action taken by the SI-APRENDE results of the propagation of a dynamic decision network, than besides the LO's score, gets other variables like learning activities and objective's progress as well as learning objective's satisfaction for each student.

7 Description of the Evaluation Process

The evaluation process was conducted in three groups of undergraduate courses: Engineering Mathematics II, Electricity and Magnetism and, Introductory Physics of Tecnológico de Monterrey, Campus Ciudad de Mexico, taught by three instructors recognized for their extensive experience in teaching and in the study area. It had a total population of 58 students (N = 58) distributed as shown in Table 1.

Table 1. Total population of Case Study

	Focus Group	**Control Group**
Math II	15	15
Electricity and Magnetism	9	9
Introduction to Physics	5	5
	NFocus= 29	NControl= 29

The total population's division by the instructors was random, to form two groups: Focus and Control. The focus group consisted of students who used the SI-APRENDE during a specific period of time, while the control group had no access to the system and used the resources provided by the instructor from the Blackboard platform (with the same amount of learning resources in the SI-APRENDE system). The three focus groups of each course were formed by students of various disciplines or careers. They were also heterogeneous in the level of subject's knowledge, skills or even interests.

A pre-test was applied to all students in the class, grading on a scale from 0 to 100. The learning objective was the same for both focus and control group, yet the way to reach that goal was different, in the case of focus group were used the LOs contained in the SI-APRENDE system, meanwhile in the control group the activities were on paper, Blackboard or taught one on one according to course's traditional planning. After two weeks using the SI-APRENDE system, instructors applied a final test (post-test) to both focus group and control group on the same subject that the pre-Test.

The Figures 4, 5 and 6 show learning gains for each group, obtained from the average of the group in the Pre-Test, focus groups being those with higher learning gain.

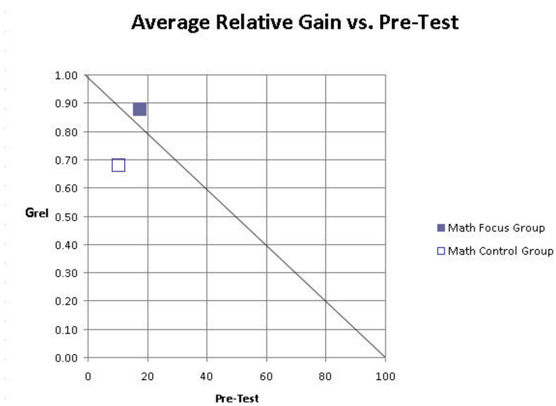

Fig. 4. Math Group

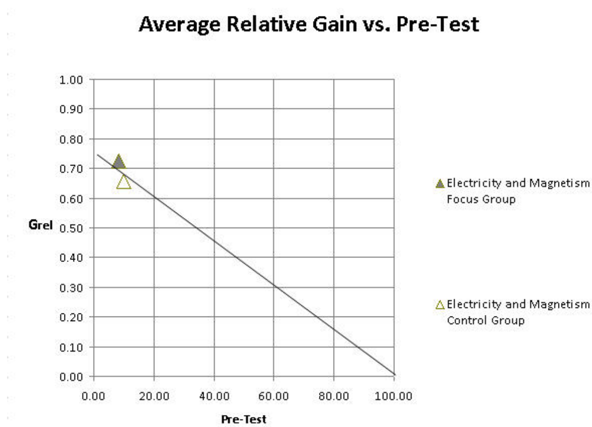

Fig. 5. Electricity and Magnetism Group

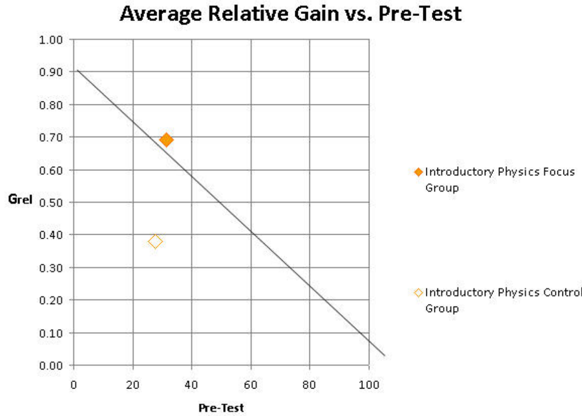

Fig. 6. Introductory Physics

8 Results and Discussion

All focus groups had higher learning gains compared to control groups. Higher learning gain is observed in the Introductory Physics group, then the Math group and finally in the Electricity and Magnetism group. Students in the course of Electricity and Magnetism, in both focus and control groups, received an instructor's personalized assistance, so that the differential in the learning relative gain was considerably reduced compared to the Physics and the Math's groups. However in this subject, the focus group also had a higher learning relative gain compared to the control group.

SI-APRENDE system allowed each student to have their own learning process, in different time and LO's sequence, depending on prior knowledge and progress achieved, both evaluated by the Tutor of this system.

9 Model Validation in Electrical Sector

SI-APRENDE is being validated in CFE (Comisión Federal de Electricidad – the National Electric Utility in Mexico). The main goal of the intelligent learning system is to certify operators in knowledge, skills, expertise, abilities and attitudes for power system's operation. Because of the fact that the operators can acquire knowledge in different ways or with different paths of learning, the tutor model of the SI-APRENDE system selects the sequence of the learning material presented to each operator. The adaptive sequence is represented as a decision network that selects the best pedagogical action for each specific operator. The decision network represents information about the tutor's current state, their possible actions, the state resulting from the action of the tutor and the usefulness of the resulting state.

10 Conclusions

The contribution of this work was to achieve the convergence between two existing tools for sequence and navigation of learning materials, such as SCORM and ITS, adding intelligence with the use of PGMs tools such as decision networks and dynamic decision networks, achieving an intelligent learning system adaptive to the situation of each student's learning.

The implementation of the intelligent learning system in the National Electrical Sector provides a more dynamic and interactive training to the Operators of Power Plants, where the employees really experience the acquisition and transfer of skills and knowledge.

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