

Conception of an E-Learning Scheme at the University of Algarve

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Abstract: With the proliferation of the Internet use, a growth of e-learning courses has been verified. We arrived to the moment where it is not enough for Universities to have standard courses to offer to the students, because there is an increasing population which tends to choose his formation according to their objectives, styles, needs and learning preferences (the student profile). This way, the universities are faced with a new challenge, which is to offer, together with the standard courses, modules specially tailored to the user desires, based on the identification of the customers needs.

In this paper, a model for the distance formation through Internet is discussed, that is being developed in the University of Algarve, which makes possible each individual to learn in agreement with his/her profile.

1 Introduction

The impact of the new technologies in the knowledge society forces to constant actualizations and reformulations in the content of the programs at all formation levels. In this context, three or four years of higher education are just the beginning of many necessary years of learning and formation in order to maintain ourselves in the professional vanguard.

Until now, most of the public and private organisms apply traditional methods to their workers' formation, supporting travel costs and lodging. This consumes time and decreases the available motivation to learn, therefore reducing the productivity and the return that is obtained by the investment.

With the proliferation of the Internet greater availability of education materials, presented in different formats (pdf, html, doc and others) and in different commercial platforms of web-learning (WebCt, Ariadne and others) has been verified. Several Institutions of higher education already offer their courses in this way to students, companies employers, other teaching

institutions, and to the remaining society, as a complement or an alternative for the traditional formation.

The e-learning process makes possible the access to the formation in any chosen place for the student (teaching institution, work place, at home), which can result in an added value of factors as a better use of the available time and an increased motivation for the learning process. However, learning in this way makes further demands to the students, such as planning, having conscience about their own capacities and limitations, besides a strong dedication in the several stages of learning, in order to avoid frustration and lack of motivation that usually leads to leave the course unfinished. Also, in the e-learning scheme, an uniform presentation of courses for different student profiles is inadequate, faced to the existence of individual styles of study, preferences and specific learning needs.

Another factor to take into account is the time dedicated by the authors in the creation of contents for courses, which is usually long. There is the need to centralize dispersed resources, in a metadata repository, under the form of learning objects, avoiding the existence of duplicated contents and other anomalies that the responsible for e-learning intend to eliminate. The reuse of the available contents should be guaranteed for the different student learning needs.

All theses facts have been worrying the responsible for e-learning, schemes which gather efforts in the research and creation of personalized pedagogic software, merging intelligent techniques with pedagogic theories, in the form of Intelligent Tutor Systems (ITS).

In this context artificial intelligence techniques have been applied, using fundamentally two approaches: the symbolic traditional approach, where an intelligent behaviour is simulated through CAI (Computer Aided Instruction) programs. Another approach is based in computational intelligence, that integrates areas as neural networks and fuzzy logic, evolutionary

computation, probabilistic or Bayesian, learning machines and data mining,

ITS are composed by a *domain model*, which incorporates the learning materials, a *tutor or pedagogic model*, which is responsible for the teaching strategies to be applied according to the student performance and needs, which are stored in the *student model*. The existence of an *interface model* is also important for implementing a good communication between the tutor and the student.

The tool that we are developing in the University of Algarve is based on two assumptions:

1- Pedagogic theories and neuro-fuzzy techniques will be used in the formulation and application phases of questionnaires; by analysis and interpretation of their data, it is possible to collect individual or common characteristics to people's groups, allowing this way the classification of the students in agreement with their profiles. These initial data, knowledge domain independent, are essential for initialization of the student model;

2 - Intelligent Tutors Systems (ITS), composed of different models (domain, pedagogic, interface and student) can be employed to implement personalized pedagogic activities, with the help of soft-computing technologies.

In this paper standards for storage and reuse of the knowledge are presented, as well as their application in the developed work. The structuring of didactic contents is also considered, through the explanation of learning objects. Following, the initial structure of the student model is presented, that has in consideration results that will be obtained through questionnaires, and the importance of overlay model in ITS, in the student evaluation. Finally, the other models of the ITS will be briefly presented.

2 Standards of storage and reuse of knowledge

The two approaches referred above have in common the interest of defining theoretical and pragmatic bases that sustain a new generation of educational systems for the identification of Internet resources. For this end, metadata standards were proposed that seek to structure the didactic contents in order to facilitate its search through labels with identifiable data.

There are some aspects to consider in the structuring of the didactic contents for Web courses:

- Content code (text, image, sound or other data) in agreement with its purpose and in any of the following formats: HTML, XML, GIF, PNG, JPEG, Flash, MPEG, MP3, VRML or others;

- Content organization in a repository, in the form of *learning objects*, to enable the potential of reuse, generative capacity, adaptability and scalability;

- Description or labels (*metadata*) implemented through languages as HTML (HiperText Markup Language), XML (eXtensible Markup Language), RDF (*Resource Description Framework*) that are independent of any technology, so that the learning objects are easily located, transmitted and accessed in a safe, easy and efficient way;

- Contents generation in a dynamic way, starting from the information contained in the knowledge data bases (*domain model*) and that satisfies peculiar needs of learning known by the *student model*. This last idea will give rise to the intelligent processing of learning objects that will be approached later, allowing sequences to be generated through a STI.

Some organizations were responsible for the creation of metadata standards [1]:

- The Dublin Core Metadata Initiative (**DCMI**) was the first to formalize the concept of metadata for the Internet resources identification, through the famous Dublin meeting, in the middle of the nineties. Now it is still used at education level and works in collaboration with the standard LOM in the development of Web metadata specifications. These standards use mechanisms that allow the independence of technologies and avoid redundancies;

- The Institute of Electric Electronics Engineers (**IEEE**) developed one of the more common standards of metadata to education level, designated for Learning Object Metadata (**LOM**);

- The Learning Technology Standards Committee (**LTSC**) is the responsible organism for specifying the syntax and the semantics of the education metadata and the access to objects through a minimum group of properties. This organism also contributed to the creation of the standard LOM;

- The Advanced Distributed Learning (**ADL**), created the standard SCORM ;

- The Instructional Management Systems (**IMS**) of Global Learning Consortium, defined and developed new specifications for inter-operationality of the learning technologies including metadata, administration and accessibility of the contents;

- The Centre Européen of Normalisation and Information Society Standardization System (**CEN/ISSS**), also has contributed to the development of the LOM standard, taxonomies, vocabularies and in the development of EML (Educational Modelling Language) language,

originally developed by the Open University of the Netherlands;

The technological tendency is to develop and structure didactic contents in the form of identifiable learning objects, which contain enough instructions to be independent of other objects and comprehensible in any context where they are inserted. In this way, it is more advantageous to think in the development of small learning objects as: text, graphs, illustrations, outlines or others, that contain instructions that can be shared or reused in different contexts or that can be combined to create blocks of larger instructions, so they can be transmitted in packages of learning contents corresponding to courses, chapters or complete sections. Each package has equally been associated with a label in XML that describes its own characteristics, particularly the organization of the learning objects in the package and their metadata.

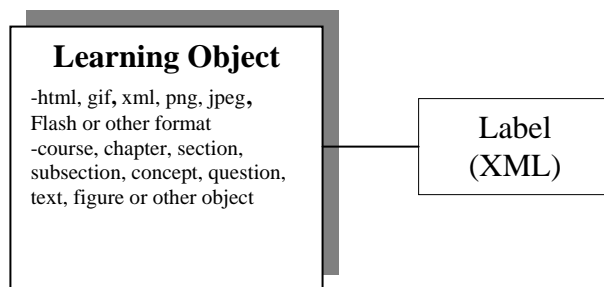


Figure 1- Learning object associated with an identifiable label

The information contained in the label of a learning object is known as the *metadata* of the object that means data on the data or information on the data, consisting in a group of document properties that allows to identify and to describe it. For example, we can make the analogy between a learning object located in data base of knowledge (domain model) and a book located in the shelf of a closet, where the object metadata of book corresponds to the registers that include several information based on the title, author, publication date, editorial, classification, etc.

The organisms that developed the standards are responsible for establishing the necessary information to describe the learning object through their metadata. That information becomes useful to know where the resource can be used, its level of difficulty, language, version, etc. For the design of learning objects metadata the standard LOM emitted by IEEE proposed the categories of descriptors [2] is described below:

- The *General* category groups the general information that describes the learning object as a whole.
- The *Lifecycle* category groups the features related to the history and current state of this learning object and those who have affected this learning object during its evolution.
- The *Meta-Metadata* category groups information about the metadata instance itself (rather than the learning object that the metadata instance describes).
- The *Technical* category groups the technical requirements and technical characteristics of the learning object.
- The *Educational* category groups the educational and pedagogic characteristics of the learning object:
 - Pedagogic type (Active, Expository or Indefinite);
 - Pedagogic classification of the resource in agreement with a pedagogic theory;
 - Specific type of the resource that can be hypertext, Video Clip, Exercise or other;
 - Pedagogic approach used by the resource (inductive, deductive or exploratory);
 - Granularity or relative size of the resource (Course, Study, Chapter, Section, Subsection, other);
 - Level of Interactivity between the user and the resource;
 - Semantic density, that understands each other for the relationship between the whole content and the time of use;
 - Education use:
 - Habitual use of the resource;
 - Description: comment on how the resource will be used;
 - Concept (prerequisite) necessary for the frequency of the course, chapter, section, subsection, etc;
 - Education Objective: the learning result intended;
 - Level: population objective in terms of degree;
 - Difficulty: the relative difficulty of the resource;
 - Duration: approximate time that the student should take to work with the resource;
- The *Rights* category groups the intellectual property rights and conditions of use for the learning object.
- The *Relation* category groups features that define the relationship between the learning object and other related learning objects.

- The *Annotation* category provides comments on the educational use of the learning object and provides information on when and by whom the comments were created.
- The *Classification* category describes this learning object in relation to a particular classification system.

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<?xml version="1.0" encoding="iso-8859-1"?>x
<!DOCTYPE rdf:RDF SYSTEM
...
<dc:title>Repository of soft_computing</dc:title>
<dc:language>pt</dc:language>
...
<course>
  <course_name>Neural_Network</ course_name >
  <item>
    <dc:title>Introduction to Artificial Neural
Networks</dc:title>
    <dc:language>en</dc:language>
    ...
    <lom-life:version>version 1.0</lom-life:version>
    <lom-life:status>Draft</lom-life:status>
    <dc:creator>Antonio Ruano</dc:creator>
    <dc:format>
      <dcterms:IMT>
        <rdf:value>html</rdf:value>
      </dcterms:IMT>
    </dc:format>
    <lom-edu:interactivityType>Expositive</lom-
edu:interactivityType>
    <rdf:type>lom-edu:Lecture</rdf:type>
    ...
    <educationalUse>
      <role>students UAL.</role>
      <prerequisite>not necessary</prerequisite>
      <educationalObjective> waited that has
acquired some basic concepts of neural networks in the
end of this chapter.</educationalObjective>
    ...
  </educationalUse>
</item>
</course>
</rdf:RDF>

```

Figure 2 - Screen for inserting metadata relative to a learning object created in RDF.

For the implementation of our metadata group, the standard LOM proposed by the IEEE has been adopted, so that the durability of the solution and the independence of the technology

is preserved. For the implementation of the metadata, presented in Figure 2, it is necessary that communication is performed through a common language, independent of technology, such as XML, RDF and DTD. The XML language, proposed by W3C [3], presents advantages compared with HTML, for being one meta-language used to define other languages, as for example XSL, RDF, besides others. XML is a pattern for exchanging information among different platforms and a tool that allows to create structured documents, where clearly there are separate contents of meaning and also of presentation. As an advantage, the content can be presented in different formats unlike the traditional plane pages written in HTML.

RDF [4] is a resource created through XML, used in the modelling and writing of data. It allows representing metadata like: title, author, modification date of a page, etc and it is based on the idea of the web identifier, known by URLs (Uniform Resource Identifiers).

A DTD [5] (Document Type Definition) document was also implemented to define the structure of the previous RDF.

The specification of a DTD is a part of the specification XML, being optional and not hierarchical (therefore linear). It consists in a group of rules that define the structure of the document which defines which elements should be used and the order they should be put. The syntax of a DTD document can be found in [5].

3 Structure of the Student Model

As it was referred, the purpose of this work is a scheme that makes possible to each individual or group to learn in agreement with their objectives, previous experience, styles, motivational states, needs and other learning preferences.

The proposal seats in the production and availability of first-degree courses, postgraduate degrees, and life long life formation, aimed to entities as: students, companies' employees, other teaching institutions, and remaining society, as a complement or an alternative to the traditional formation and adapted to the students characteristics.

To develop this system, adapted to the potential candidates characteristics, it is necessary to know the elements that the learners feel more comfortable in what refers to the inputs, processing, perception and acquisition of the knowledge, as well as reasons that can cause indifference and lead to an unsuccessful formation. We will shortly proceed with the auscultation of the population opinions, through sending and receiving an e-mail. Additionally a questionnaire will be available in an Internet

site, with the objective of facilitating the answers of the persons contacted, and, if possible, to collect information of other organizations that have not been contacted.

The formulation of the questionnaire will be based under the lines of questionnaires construction of Matalon [6], sustained by pedagogical theories related with learning styles and multiple intelligence theory of Gardner [7], and Armstrong [8], that allow us to determine which characteristics should be looked for in the candidates and how to identify them. As an exaggerating number of questions can reduce the success of the inquiry, multi-variate statistical methods based on the discriminant function [9] (classification rules and separation of groups) will be used, to reduce the number of questions.

After the phase of collecting answers, this data will be analysed and interpreted, with the intention of obtaining widespread conclusions, that are useful for identifying different profiles in the population. These initial data, independent of the knowledge domain, are necessary for initializing the student model. The last information is related with levels of the student competence related with the elements of the domain model, such as study times and pre-acquired concepts. To process the answers of the inquiry a system based on rules will be used. This will allow accomplishing a qualitative evaluation of the answers to classify the students.

The key for a personalized, intelligent and realist teaching is, without doubt, the initial knowledge that the system should store about their users in the student model, which influence the type of contents and examples to be made available in the initial phases of contact with the system. This knowledge will be updated through the student's interaction with the system.

The basic structure of operations accomplished by the student's model is illustrated in figure 3.

There are some techniques or models that have been used in the implementation of the student model [10], [11]:

- The differential model, where the student answer is compared with the base of the knowledge in the domain model; this means that the specialist's and student performances are compared, and not their knowledge;
- In the overlay model, the student model is represented as a subset of the knowledge domain (domain model). This last model assumes that the mistakes or misconceptions of the student behaviours are always caused by ignorance or knowledge lack due to the absence of the

knowledge in the domain model; it forgets that those mistakes can also be caused by misconceptions in the student mind;

- The buggy (or disturbance) model also relates the student knowledge with the domain knowledge and it assumes that the student mistakes are due to misconceptions of some concept or absence of it;
- The simulation model analyzes the student behaviour in a certain situation and after that it assumes that a great variation will not occur;
- Finally the faith model consists in a group of faiths that contemplate the learning degree that is assumed that the student possesses on a certain concept.

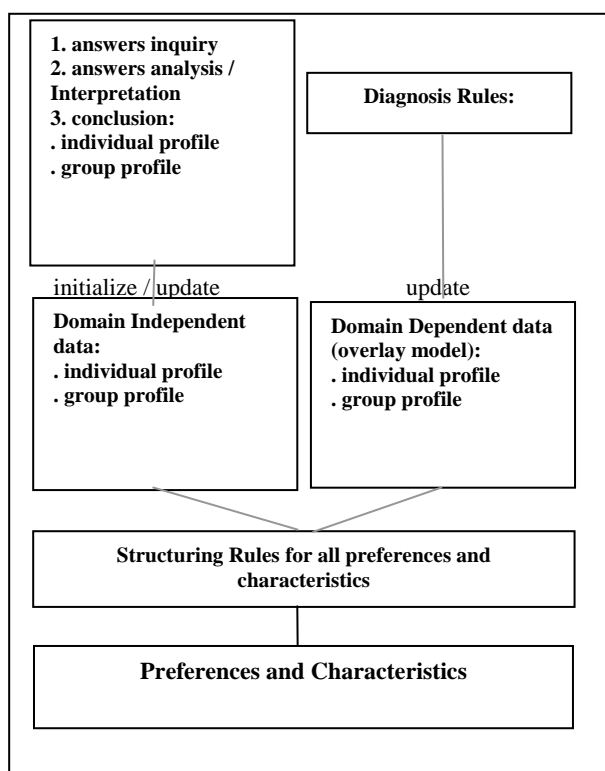


Figure 3- Structure of basic operations of the student model

For our implementation, we will use the overlay model, that consists of a subset of the domain model contained in the student model (see figure 3), with the competence levels related with the learning objects or learning packages (concept, subsection, section, course or other) of the domain model.

We shall return to this subject in the section related with the evaluation to the student knowledge. Also here neuro-fuzzy techniques [12], [13],[14] are very useful to improve the STIs, by extracting information contained in the student registers, to obtain a true picture of the possible knowledge levels and learning roads.

4 Structure of knowledge (Domain Model)

Any educational system that integrates intelligence, domain knowledge and that is capable of solving problems, has a central part designated by the *domain model*. This model is usually linked to the student model and it is fundamentally a knowledge data base constituted by didactic materials, examples, questions, simulation processes, among others. Several models exist for the representation of the knowledge like semantic nets, frames, scripts, production rules, among others.

Our choice lies in the structure of the knowledge represented by a linked tree of contents to a network of concepts, where the learning objectives are also associated, like in [12].

The key for the creation of a personalized, intelligent and realistic educational system is based on the structuring of the knowledge domain in learning objects, in such a way, that is possible to be adapted.

In the present study, some of the following steps were already implemented, however only after analysis and interpretation of the results obtained in the initial inquiry is performed, the remaining ones will be implemented:

- 1) To subdivide the contents in topics in agreement with the needs that are supposed to be requested. Please note that, if some topics are not appropriate for all the student profiles, these should be separate for an eventual exclusion of the group of topics that they will be made available;
- 2) To separate theoretical from practical contents in order to adapt the contents to the each students' learning style and other specific characteristics;
- 3) It is also inevitable to make assumptions on the previous knowledge of the student before the presentation of the learning object. This idea is similar to the structure of the sections in a book so that it is not necessary to read them in the pre-defined order;
- 4) To project several pedagogic activities (also to be included in the pedagogic model) with the contents appropriate to the students profiles;
- 5) To make available appropriate ways of navigation, and interaction to the students.

Our structure of the knowledge is based on a network of concepts and a tree of concepts as it exemplified below.

The relationship between the several concepts and their prerequisites is exemplified in figure 5. As it can be seen, Concept1.1-1 is a prerequisite of Concept1.2-1 and Concept2.2.2-1 is a prerequisite of Concept2.2.2-2.

Chapter 1	Section 1.1	Concept1.1_1
	Section 1.2	Concept1.2_1

Test1		
Chapter 2	Section 2.1	
	Section 2.2	Concept2.2.1-1
	Section 2.2.1	
	Section 2.2.2	Concept2.2.2-1
	...	Concept2.2.2-2

Test2		
Chapter 3	Section 3.1	Concept3.1.1_1
	Section 3.1.1	Concept3.1.1-1
	Section 3.1.2	Concept3.1.2-1
	Section 3.2	
	Section 3.2.1	Concept3.2.1-1
	Section 3.2.2	Concept3.2.2-1
		Concept3.2.2-2
		Concept3.2.2-3
Test3		

Figure 4 - Structure of knowledge

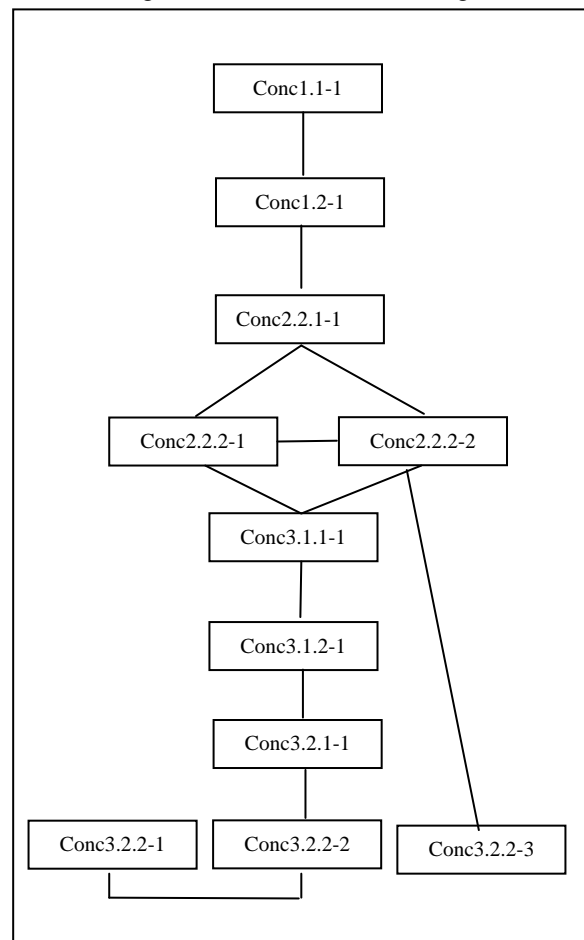


Figure 5 – Tree of concepts (relationship between concepts and their prerequisites)

5 Evaluation of the student's knowledge

The typical student evaluation is accomplished through the answer to one or more questions. These evaluation objects are stored in the knowledge data base, as the remaining learning objects. The questions can be of several types, like: multiple choice, matching, calculated, short or long answers [18]. The attributes of the questions are: level, complexity and others related with the object metadata previously referred.

As it was referred before, the evaluation of the student's knowledge is based on the overlay model [12]. This model was originally developed in the area of ITS, starting from the student's model [17].

The number of correct and incorrect answers is evaluated through the overlay technique; that is; the answers given are compared with the information available in the domain model through evaluations at the level of the student knowledge. A group of questions and exercises are proposed to detect the student's level knowledge.

For the determination of the competence levels of the students related with each learning object or package, the overlay model stores a value (integer, real, logical, character, text) or a structure (estimate vector or a group of values), where to each object a range of values should be associated, which is an estimate of the competence level of the student's on that object.

In this approach each concept is associated to a range of linguistics values that characterise the knowledge level of student. The range of linguistics values can be, in this case: **{very insufficient, insufficient, almost insufficient, almost sufficient, sufficient, very sufficient}**. This is a scale of values very close to that is used by an human tutor in the students' evaluation. A neuro-fuzzy system will be employed for this purpose, as these systems adapt well to the qualitative answers, very common in this systems [15][16].

6 Pedagogic Model

The pedagogic model contains the strategies of how to teach; that is, how to present with success each topic to the student through effective teaching tactics starting from diagnoses previously accomplished.

The STIs frequently employ the Socratic method [19], where through questions and dialogues, the student is conducted to his learning goal. It is also typical in this type of systems to employ to the coaching model using activities of entertainment, games and others[20].

This model accomplishes 2 functions:

1- Interface configuration - it analyzes the student's model and determines which attributes of the interface should be activated. This model has to select files of the domain model that should be loaded in the monitor, defining the content to present and the form of the interface model;

2 – Student's model update – it defines the way that the STI classifies the student, analysing the actions of the student on the interface. The knowledge of the relationships between characteristics and attributes allows to select the characteristics that should be activated when an attribute is selected by the student.

To accomplish these activities this module should process the student's inputs, and to evaluate if they are consistent with the existing student model or otherwise to modify it. With the help of the neuro-fuzzy system, the pedagogical model will select strategies that are better adapted to the objectives and styles of the student's learning.

7 Interface Model

A good interface is vital for the success of any STI, as it is through interaction that ITS presents the didactic material to the student and later evaluates the progress based on their answers. This model will contemplate some adaptive capacities of the system, allowing through appropriate means (text, sound, image, video, animations, and simulations, examples) to present the didactic material to the student and simultaneously register information of the interactivity resulting from that communication.

8 Conclusions

More and more the universities should have present that they have the need to invest in techniques and innovative educational models for knowledge distribution, with updated contents. These can be applied to attract and maintain the student interested since the beginning of the course to its conclusion and to answer the expectations and learning needs of each one, in order to allow to guide them or to reorient its job path. Existing e-learning schemes usually do not integrate the main teaching /learning theories in their conception, and for this reason their results have not been very satisfactory.

Through our project we intended to create conditions so that the University of Algarve can make available, in an effective way, life-long learning formation, and to complement its first-degree and postgraduate degree courses.

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