LEARNING OBJECTS AND PERSONALIZED INSTRUCTION

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Summary: This paper describes the analysis and design of learning objects including personalized instruction. The above is based on the inclusion of artificial intelligence techniques via intelligent learning systems. In this case, the intelligent learning system becomes immersed in the learning object and one of its classifications is personalized learning. The sphere of application selected is that of structured programming. This paper is inspired by the fast-paced development of new technologies and their inclusion in different applications for the purpose of maximizing progress.

1. Introduction

One of the main advantages of e-learning is ease of access. Education is available to more people due to the removal of barriers in space and time.

Distance Education (DE) is defined as the distribution of education which does not force students to be physically present in the same place as the instructor. On a basic level, DE takes place when students and teachers are separated by physical distance and technology (voice, video, data, and printing), often in combination with face-to-face classes and is used as a bridge in order to reduce this barrier (Distance Education at a Glance).

At the present time, a wide range of electronic media are used to send or receive support materials for the purposes of DE, which has led to e-learning. This term refers to the use of new information and communication technologies for the purposes of teaching. One of these technologies is the Internet, but we can also include the concept of multimedia and simulators. It could be said that e-learning is a form of distance education by means of which both the teacher and the student make use of electronic media to carry out the teaching-learning process.

Since the eruption of Internet into our lives, opportunities for access to academic education have increased to the extent that the network provides us with access to more people and provides more complex, elaborate learning environments. One of the main advantages of e-learning is ease of access. More people can access academic education due to the removal of barriers in time and space.

Over the last few years, the use of e-learning or LMS (Learning Management System) platforms in Universities and Educational Institutions has increased. There have been proposals for the designing of distance courses using educational technology and each institution has online materials for various disciplines, as well as online materials for the same discipline in the same academic department.

These new media are being used to express knowledge, to present information, and to guide learning activities in the materials. An increase in richness of content represents, without doubt, a change in the educational context, but this is not a minor change, instead it is accompanied by more in-depth changes to the way educational content is organized, to the way in which it is accessed and its use in the learning-teaching process.

This paper is organized as follows. We will provide an explanation of intelligent learning systems as well as of the general teaching model in Section two. We will provide a description of learning objects and the characteristics which make them innovative in Section three. Section four will describe the sphere of application and its organization. Section five will describe the design of learning objects in this context. Finally, Section 6 will provide our conclusions.

2. Intelligent Learning Systems

Intelligent Learning Systems (ILS) are made up of four components: 1) the expert module, 2) the student model, 3) the interface, and 4) the user. A brief description will be provided below. For more information, consult Laureano-Cruces, et al. (2000).

The Expert Module is where knowledge that the system tries to teach the student is collected. The implementation of this component is closely linked to the tutor module due to the fact that the tutor will teach by placing emphasis on the organization of the expert module. Therefore, it is important that this module is organized in a pedagogical way.

The Student Model is a database that contains information about the student, thus allowing us to carry out the following: 1) adjustment of the system based on the student’s ability in relation to a specific subject (teaching object); 2) preparation of a report of material covered according to the curriculum; 3) selection of the correct level of intervention and explanation; and 4) provision of feedback from the student.

The Tutor Module is responsible for deciding what actions to take in order to teach or correct a specific dominance based on information from the curriculum (Section 4) and on the objectives of the planner; in relation to one or several specific subjects to be taught. It selects the problems to be shown to the student, analyzes the answers, presents solutions to certain problems, or decides to show examples. It manages educational material and is responsible for selecting the most suitable material based on reported situations. These situations are mainly determined by the planner’s demands and the student’s behavior as observed through the interface.

The Interface can be considered to be a simulated environment since it is where input and output from the system are represented. Its basic responsibility is to communicate between the system and the student, although the fact that it is the output for ILS activities means that it also has an educational responsibility.

In this case, we have designed an ILS for subsequent execution. Said execution will be encapsulated in a learning object. In order to achieve this, we will develop an inference engine which will be linked to the tutor module and to the user’s observed behavior.

The general educational model used in this execution will take into consideration the nine elements of Table 1.

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1 The planner is understood to be the place where selection control methods and sequencing of teaching strategies are implemented. It can be implemented as a separate component or as part of the tutor module depending on the selected control mechanism.
Said model is inspired by human behavior. These elements are linked through causalities, which allow them to take into consideration the influence of each one on the rest. The form of representation selected in order to bring to life this inference engine is a technique known as diffuse cognitive maps and belongs to the area of cognitive engineering and investigative methods. The specific development of this area is not discussed in this article. For more details, review Laureano-Cruces, et al. (2008).

The node referring to incentives produces different ways for the system to interact through the interface and for all information relating to the student model to be taken into consideration, such as errors, material covered, learning style, internal learning objective, and emotions.

Table 1: Causal matrix for general educational behavior.

<table>
<thead>
<tr>
<th>Interest (1)</th>
<th>Desire (2)</th>
<th>Help (3)</th>
<th>Cog/op strategies (4)</th>
<th>Interruption (5)</th>
<th>Abandonment (6)</th>
<th>Learning (7)</th>
<th>Inactive Times (8)</th>
<th>Errors (9)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0</td>
<td>1</td>
<td>-1</td>
<td>0</td>
<td>-1</td>
<td>1</td>
<td>-1</td>
<td>-1</td>
</tr>
<tr>
<td>2</td>
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<td>0</td>
<td>-1</td>
<td>0</td>
<td>-1</td>
<td>1</td>
<td>-1</td>
<td>-1</td>
</tr>
<tr>
<td>3</td>
<td>-1</td>
<td>-1</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>4</td>
<td>1</td>
<td>1</td>
<td>-1</td>
<td>0</td>
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<td>1</td>
<td>-1</td>
<td>-1</td>
</tr>
<tr>
<td>5</td>
<td>-1</td>
<td>-1</td>
<td>1</td>
<td>1</td>
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<td>-1</td>
<td>1</td>
</tr>
<tr>
<td>6</td>
<td>-1</td>
<td>1</td>
<td>1</td>
<td>1</td>
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<td>-1</td>
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<td>1</td>
</tr>
<tr>
<td>7</td>
<td>1</td>
<td>-1</td>
<td>0</td>
<td>-1</td>
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<td>0</td>
<td>-1</td>
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<tr>
<td>8</td>
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<td>1</td>
<td>-1</td>
<td>0</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>9</td>
<td>-1</td>
<td>-1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>-1</td>
<td>1</td>
<td>0</td>
</tr>
</tbody>
</table>

3. The learning objects

The Learning Objects (LO) Model provides a new way of organizing content in a compositional hierarchy of granularity. This content ranges from multimedia objects, informative objects, and learning objects, to accumulations of more complex educational content such as sections, units, courses, study programs, etc. It provides a way of constructing educational content based on pieces of elements from lower levels, as well as a way of looking for content objects: locating them, recovering them, and integrating them via a collection of specifications and standards for their cataloging, requisitioning, exporting, transporting, and importing. Finally, it provides the opportunity to create, for each student and each instant, a personalized selection of educational content offering optimum context for their learning process.

What are learning objects? We can begin by using the concept provided by the Mexican workgroup belonging to the University Corporation for the Development of Internet 2, which has generated the following operating definition:

A learning object is a digital informative entity developed for the generation of knowledge, skills, and attitudes required for the performance of a task, which makes sense based on the needs of the subject using it and which represents and corresponds to a concrete reality that may be manipulated. Likewise, desirable properties of the objects have been defined as follows:

- **Subjectivity** – Objects are versatile since the significance of their potentials depends on the subjects using them.
- **Reality** – The learning object is a bridge with a concrete reality.
Historicity – The historical relevance of the objects depends on their construction and distribution based on real terms of access and use by students who are to be assisted.

Complexity – Although objects have limits that turn them into material units, they are linked in multiple forms to other possible objects.

Ability to be Communicated – Learning objects contain information and their ability to be communicated requires the integration of multiple languages.

Integrality – Existence of units which, when accessed individually, already have a structure and direct us to a specific learning object.

Coherent Unit – Objects as small learning units, the elements of which have an intimate relationship with the object.

Self-Containable, Versatile Units – Each object can be considered independently and in a flexible way.

Reusability – Each object can be used in different contexts and for different objectives.

Scalability – The objects can be grouped into a large collection of content in order to create the structure of a course.

Classifiable – Each object must have certain elements which allow it to be classified in a meta-data (descriptors) and with properties allowing it to be easily found.

Relevant – It should respond to a requirement that is relevant and which contains a deployment schedule.

Figure 1. Components of the Meta-data.

The popularity of educational design based on learning objects has increased over the last few years and has become one of the main trends in the field of education as a result of information and communication technologies. The anatomy of a LO can be seen in Figure 1. This figure shows us how the ILS is immersed in one of its components.

4. Organization of the “Structured Programming” Teaching Domain

According to Estevez (2002), we tackle serious problems when we ask ourselves: 1) are students really learning?: 2) what level of application is there for the acquired knowledge in the environment for which they are preparing?: 3) is the knowledge enough to continue with higher education?: and 4) due to the pace of scientific and technological development in relation to knowledge in various disciplines, when will what they have learned become obsolete?
From this point of view, we aim to enrich the education design using cognitive science in order to include processes of this type in teaching and learning by designing and using cognitive strategies. Thus, the proposal of these innovative models is based on: 1) a multinodal perspective (based on different theoretical sources); 2) a holistic, integral approach (knowledge, skills, attitudes, and values…); 3) a favoring of the use of cognitive strategies as a way of activating the mental processes required to encourage learning; 4) use of the cognitive components of the skill to acquire including the expert's own mental models.

**Didactic Design**

This design refers to the consideration of the “curriculum” defined in terms of the global project in which the concrete activity is included; and, in the case of specific terms, it refers to what all teachers should know about their teaching material in order to encourage its learning.

Thus, the didactic design is conceived as a body of knowledge that is concerned with: 1) the understanding, improvement, and application of teaching methods; 2) the optimal combination of methods; and 3) the contexts or situations in which it is expected that said teaching methods will produce the best results.

The result of a didactic design is known as a model and this is the final representation of a collection made up of strategic components which will allow us to: 1) put the material in sequence; 2) use conceptual models; 3) use examples; 4) incorporate practice at a specific time; and 5) use strategies to motivate students. Another important aspect of this didactic model is that it needs to show the different aspects at work in teaching in order to achieve desired objectives in the best way possible and in accordance with anticipated terms and conditions. Figure 2 shows the conceptual model that will be used to organize didactic material and is based on that which was developed in Cruz-Miguel (2006).

![Figure 2. Conceptual Model of the “Structured Programming” Domain](image-url)
Instructional Objectives

In this section, an instructional objective (IO) is linked to each concept or skill. The IO is represented by the cognitive skills and capacities that the tutor wishes to transmit to the student, which may be classified in accordance with the following taxonomy (Bloom, 1956):

- Knowledge
- Understanding
- Application
- Analysis
- Synthesis
- Evaluation

In the context of the domain in question and in accordance with Gutierrez (1994), three IOs will be used, although understanding is required for the application. Below we will define and link them to our domain:

**Knowledge** – This objective is linked to the memorizing of knowledge by the student.

The student needs to know the theoretical concepts divided into definitions of the different types of abstractions (procedural and functional), type of data, types of parameters (reference and value), control structures (sequence, repetition (conditional, non-conditional)), and selection (simple, multiple)).

**Application** – This objective is linked to the implementation of previously learned knowledge.

According to Laureano *et al.* (2004), the student will correctly apply the procedure in order to be able to:

1) Understand the use of different types of abstraction, which provides us with the model for structured programming.
   a. Passage of parameters and their types.
   b. Types of abstraction: functional and procedural.
2) [Use] The kind of control structure, ad-hoc for the system being created.
3) Qualify the use of different types of information in accordance with the characteristics of the problem.

**Analysis** – Is used to teach the student to analyze the states of different settings, to analyze the different states depending on reasoning (Laureano-Cruces *et al.*, 2004) involved:

**Prediction** – Action or effect of announcing what will happen based on incomplete information in a possible future.

**Post-diction** – Explanation of how we have arrived at a current concrete situation, equivalent to a retroactive prediction, which is why it is considered to be a non-deductive type of reasoning, also known as abductive logic. This type of reasoning is made up of two phases: the first is a set of possible explanations and the second is the construction of explanations and the selection of the best.

**Quantitative Interpretation** – Given the partial description of the peculiarities of a situation and observations of its behavior, conclude that other peculiarities exist and that more may occur.

**Causal Reasoning** – Cause-effect. This type of reasoning is a tool which gives credit to a hypothesis originating from an observed or postulated behavior. It is useful for the generation of: explanations, interpretation of measures, planning of experiments, and obviously learning.

The student will analyze a specific state of the scenario and should be capable of understanding what is happening based on the values of the different parameters and their relationships with the other elements.
Once the instructional objectives have been established, they need to be refined in the instructional plan in terms of the activities that need to be carried out both by the professor as well as the student. These activities will be known as instructional strategies — they are responsible for providing the student with exercises, for motivating the student, for sending the student communications via the system (by means of explanations, comments, a graphic example, etc.), and for providing continuity to the instructional session. We achieve the above as a result of interventions by the system through the interface.

5. Design of Learning Objects

In order to design learning objects, we will adopt the methodology proposed by Muñoz (Muñoz-Arteaga, et al., 2008).

Methodology

The methodology proposed for this project is composed of four phases for the design of the LO. Said phases are described below:

Phase I: “Analysis and Procurement”

During this phase, general information for the Learning Object is identified. The composition of didactic material for the construction of the LO is obtained. This is closely linked to the instructional objectives which, in turn, are linked to the conceptual model.

Phase II: “Design”

During this phase, each of the components of the LO are identified as well as their interaction with elements of the general structure of the LO. It is worth mentioning that this phase is one of the most important, as it is during this phase that the pedagogical part of the LO is specified.

This phase includes the analysis and design of the ILS, which includes identification of the objective, personalized instruction, content, activities, and evaluation by means of scenarios and types of errors.

It is worth mentioning that the parameters were established in order to measure elements of the general didactics (Laureano-Cruces, et al., 2008), and that they were established in Table 1. Said elements are connected with the environment of structured programming.

<table>
<thead>
<tr>
<th>Elements</th>
<th>Parameter connected with the programming environment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interest</td>
<td>Predetermined as being present when entering the system and modified by the effect of the rest of the elements.</td>
</tr>
<tr>
<td>Desire</td>
<td>Predetermined as being present when entering the system and modified by the effect of the rest of the elements.</td>
</tr>
<tr>
<td>Help</td>
<td>Request for and execution of help.</td>
</tr>
<tr>
<td>Cog/op strategies</td>
<td>Application of strategies.</td>
</tr>
<tr>
<td>Interruption</td>
<td>Interruption of the task by the system.</td>
</tr>
<tr>
<td>Abandonment</td>
<td>Exit from the system.</td>
</tr>
<tr>
<td>Learning</td>
<td>Task correctly completed (right answers).</td>
</tr>
</tbody>
</table>
Inactive Times

Time established by the expert and measured using the operating system’s clock.

Errors

Errors made.

The elements in the first column are the nine elements that describe the general didactics (Laureano-Cruces, et al., 2008). The second column describes how to measure and what should be used to measure each of the elements of the didactics.

Generation of the Meta-data

In order to generate the meta-data, we need to describe the LO to facilitate the management of cataloguing, searching, and recovery. In order to generate this meta-data, we will use the SCORM standard for LO design. The SCORM meta-data is based on the IEEE1484-12-12-1-2002L standard of TSC * Learning Object Meta-Data (LOM), which specifies the general characteristics of the meta-data of a LO.

Phase III: “Development”

This phase is responsible for the assembly, packaging, and storage of the LO in the repository. In order to assemble the LO, we need to integrate each of the components in an XML template which contains the general information relating to the LO. The packaging needs to be generated using the SCORM standard so that the meta-data can be created and edited. The LO needs to be stored in a LO repository.

Phase IV: “Integration of the LO in an Administration System”

In order to be able to efficiently manage the LOs, an Administration System is needed to support the integration of all activities such as online courses, chats, exercises, exams, etc., for the purposes of providing a collaborative environment.

6. Conclusions

This project aims to use techniques of artificial intelligence together with new technologies in order to create systems that provide the user with both knowledge of a specific domain, as well as the ability to obtain self-regulatory learning strategies. The above is carried out using the general didactic model developed for the tutor. The fact that the LOs have development and access standards allows for their increased use.

The aim of this project is to support and benefit the Individualized Learning System (ILS) of the Universidad Autonoma Metropolitana, Azcapotzalco Campus, through the generation of LOs which can be used to support students and teachers. We can achieve the above if learning objects are designed using the Sharable Content Object Reference Model (SCORM) standard. The above will allow us to share content from different platforms located in other universities or organizations that share the same application domain in order to maximize the use of new technologies such as e-learning using learning objects and artificial intelligence techniques.

We are currently in the development phase of a cognitive structure of ad-hoc emotions for the learning-teaching environment, which will allow the tutorial system to participate in a way that more closely respects the activities of the user, as well as the design of different scenarios relating to the different LOs.

References


