PACEL PROJECT: LEARNING OBJECTS IN MATHEMATICS

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Introduction

In every educational institution the teaching of mathematics has had to face growing and more specific problems, especially in relation to modern students' attitude towards this discipline coupled with a general decline in students' mathematical abilities. Teachers and lectures are finding that mathematics is held in low regard by many students who fail to apply themselves and as a consequence have more difficulty in mastering the subject.

For this reason it seems to be useful to introduce into high school and university courses some activities which can make the students more involved in learning mathematical concepts connected with their applications. Usually teachers need to be supported with specific instruments in order to present the contents (concepts and applications) in an integrated manner and related to the curriculum.

Furthermore the use of e-learning integrated with other learning activities (blended learning) is quite effective for motivating the students and improving the quality of learning, then the use of e-learning platforms becomes widespread. In this context the production of standard Learning Objects (L.O.) is crucial and useful in order to allow the implementation of e-learning modules.

The use of Learning Objects can create atomic resources based on the granularity of the contents. In this way flexibility in teaching and learning is ensured. The L.O. may be re-used for teaching different levels and in courses of different disciplines. Teachers and students can build flexible and personalized learning paths by selecting the contents. The resources can also be shared in different learning environments.

The aim of the project is to create a set of L.O. which can be used to present some fundamental mathematical concepts The objective is to produce multimedia structured in a manner which allows teachers to connect the theory and the applications in a very flexible way using a model which integrates both aspects in a form which promotes real understanding and the acquisition of calculus instruments related to them. Each concept is expounded with a set of problems in Economics, Physics, Statistics and Finance which are typically used as examples of applications.

The project

The description of the model can be done via a schema based on five steps:

1. Presentation of a typical problem within one of the contexts
2. Mathematical description of the concept that can be used to formalize the problem
3. Examples of the concept with calculus
4. Logical development of the concept
5. Application of the concept for the solution of the problem in point 1.

In order to organize the contents of the materials, two distinct aspects are considered for each concept: **level** and **context**. Two levels especially are taken into consideration: high school and university (graduate level) and the context within these can be Economics, Physics, Statistics or Finance.
Points 1 and 5 are related to the context and, in some way, are independent from points 2, 3 and 4. For each concept, two macro-stages should be considered:

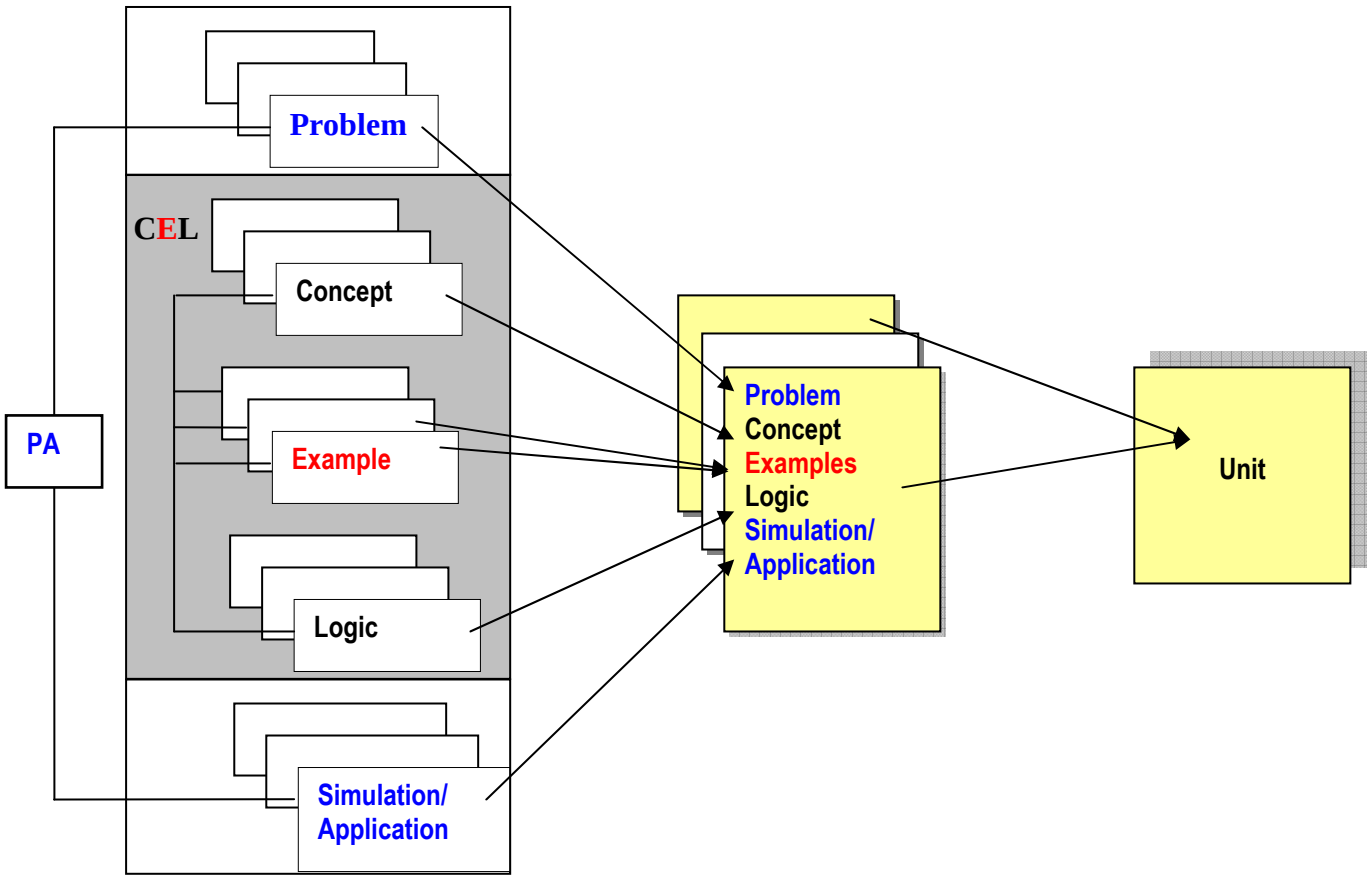
Context -> PA: Problem + Application
Levels -> CEL: Concept + Examples with calculus + Logical development of the concept

The project starts with the realization of a prototype regarding a particular mathematical topic and the implementation of L.O. of the five types following the steps:

1. Setting of a concept

2. Choice of the context and the problem
3. Production of the text of a mathematical core (CEL)
4. Realization of different macro-stages (PA one for each context)

The following schema describes the relations between the five types of L.O. and the organization of the database in order to achieve the units. The L.O. can be organized in blocks composed by five L.O., each e-learning unit is produced using such blocks connected differently.



Type 1: Problem

The problem is presented using video or animation. The video can be a short movie captured in a normal live context in which the problem is presented in a very informal way.

Type 2: Concept/Logic

L.O. present the concept by means of mathematical formalism, using the correct symbols in a clear and synthetic way. The concept can be a new object (definition) or a property (theorem). The proof is an optional part and is present only for particular theorems. In order to allow the production of macro-units for two different levels (high school and graduate) the complexity of the L.O. could be different but in some way the more specialized parts should be a continuation of the basic ones in order to avoid replication of the contents. L.O. can be created via presentations with an audio track.

Type 3: Example

Examples are used to understand the concept and its practical applications. They can be produced via animations or presentations with audio tracksor software. The software used is open source (Spreadsheet, Scilab, Geogebra) in order to allow teachers and students to reproduce the simulation and to develop other similar activities.

Type 4: Simulation

This type of object presents the model of the problem which corresponds to the mathematical content. The L.O. can be created using mathematical software for symbolic and numeric calculus or geometric representation. As in type 3, the

software used is open source (Spreadsheet, Scilab, Geogebra) in order to allow teachers and students to reproduce the simulation and to develop other similar activities.

Type 5: Application

The solution of the problem is presented using video or animation similar to the continuation of the presentation of the problem underlying the usefulness of the mathematical content of the core CEL.

The video of the problem and application can be part of a longer movie which can be used for a class of L.O. concerning different aspects of the same problem or different stages of the solution to the problem.

Prototype description

The first stage of the project regards the realization of a prototype.

1. **Topic:** real functions of one or more real variables
   Concepts: definition of a function from R^n to R, restriction of the dominium of a function to subpaces of R^n , level sets, continuity, derivability, differentiability and tangent plane.

2. Production of the text of mathematical core (CEL). For each concept the text presents mathematical definitions and properties. We could either apply a revised version of previously used lessons texts or new texts, as well as graphics in order to show the surfaces and those properties and relationship. All texts are provided in Italian and English.

3. **Context**: Economics
   Problems: these should be problems which can be modelled using one of the concepts (one, two or n variables, etc.) For instance different production function (linear, Cobb-Douglas, Leontiev).

4. Realization of one or more macro-units PA and CEL.

Technologies and software tools

SCORM compliant Learning Objects are created and tested on the most popular Open Source LMS platforms, like Moodle, Ilias and Dokeos. Adobe Captivate was used to create digital contents, because it is a user-friendly software tool and makes it straightforward to create SCORM compliant LO, starting from traditional files, such as animations, videos and PowerPoint presentations. Consequently we can minimize production costs and the number of developers, while still ensuring the quality of materials. Slides, screen capturing and full motion recording for animations can be integrated. This is very important in math presentations and applications, because the learning contents must be attractive for learners as well as being effective for teachers. Adobe Captivate also enables the effortless creation of the three main components of a Learning Object: content, activities for learners and assessment.
The Learning Object is a Flash file that appears in a standard format for the Web media: Flash provides appropriate sized files as well as ensuring accessibility for Web users. Commercial software tools, such as MatLab and Derive, and Open Source tools, like Scilab and GeoGebra, are amalgamated to create math contents, using the best features of each tool, although activities in Learning Object are presented using Open Source tools, to make the individual computer exercises easier for learners.