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Abstract. This paper presents a framework for the design and implementation of learning objects using a competence-based approach. This framework is illustrated by the development of a standalone Windows application (Trilho GOA) whose primary purpose is to create standardized pedagogical contents through the aggregation and standardization of instructional resources in several formats that can be used later on a Learning Management System (LMS) supporting SCORM 1.2. The paper contains a brief introduction to the developed software, its system architecture, main features and several pedagogical advantages for its users.

Keywords: Competences, Lifelong Learning, Learning Management System, Learning Object Manager, Pedagogically oriented contents, SCORM.

I. Introduction

Some years ago, Alvin Toffler said “The illiterate of the 21st century will not be those who cannot read and write, but those who cannot learn, unlearn, and relearn”. Accessing information rapidly, being able to transform it in meaningful knowledge and performing its application in real life is essential to economic competitiveness of companies and personal development of individuals. These skills are important not only as a part of initial education but also as lifelong process that most individuals will require throughout their lives. It is in this context that e-learning strategies designed for learners that have to be autonomous in most of their learning process are crucial for the so called “Knowledge Society”. In fact, the “Knowledge Society” creates, more than never, the need for constantly developing and upgrading knowledge, skills and abilities in order to face labour market demands and changes. This also poses enormous challenges to training programs that increasingly must address competence-based curricula.
The work presented in this paper is the result of a joint project between PT Inovação, Portugal Telecom Group, and the University of Aveiro.

On the basis of this work were the following ideas:

- Enterprises need skilled workforce in order to maintain and promote competitiveness. To accomplish that, prospective studies identifying future labour needs and technological transformations taking place in the economy should based lifelong learning initiatives, pointing which knowledge and competences are required. Engaging active workers in lifelong learning will significantly improve employee productivity, desired performance and business outcomes, and individual competence development as well.
- Universities and training institutions should prepare their students according to the labour market demands and technological evolution, focusing teaching on competences, in order to face the economic and social challenges ahead. They should also stimulate lifelong learning habits.

The above ideas were further influenced by the fact that the introduction of the Bologna process creates new challenges and opportunities, in particular in the areas of engineering and technical degrees. In these areas, conventional academic curricula are undergoing profound modifications, giving rise to learning architectures were the vocational and training components have an increased role and where a strong appeal is made to autonomous work on the part of the learner. A possible approach towards the implementation of the Bologna process is based on the implementation of a problem solving or project led type of learning also known as the Aalborg Model [1], [2]. The Higher Education Classical Model and the Aalborg Model are illustrated by the following table (Table 1.).

<table>
<thead>
<tr>
<th>CLASSICAL MODEL</th>
<th>AALBORG MODEL</th>
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<tr>
<td>P</td>
<td>P</td>
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<td>S</td>
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<td>Prof</td>
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This table illustrates the fact that, in a competence development context, the professional or vocational components of the learning process go hand-in-hand with the academic components throughout a course or training roadmap. This is an opposition to the conventional, classical model were subject based learning was the basis on most of course and where professional or vocational components only appeared in its latter stages.
Features like team work, multidisciplinary knowledge management, concurrent learning, etc are some of the requirements imposed to e-learning platforms if used in the context of a problem solving or project led type of education and training, targeted at competence development. The work reported in this paper addresses the specific needs of an e-learning environment capable of dealing with such requirements.

II. Trilho Learning Roadmaps

Learning Roadmaps are conceived with different approaches, methodologies and definitions, according with who is creating them and for whom the education is targeted. The available literature is not consensual, and several companies or institutions that produce learning contents use their own methodology plan. To proceed with research, it is important to clarify and specify what the meaning of a Learning Roadmap is.

Having in mind the semantic framing of words and goals of this project, it is proposed the following definition for Learning Roadmap: "Detailed description of the life cycle of a discipline. It comprehends all contents, associated events and activities that conduce to the goal of a thematic issue. Each thematic issue is indexed with each learning mark."

Thus, it has been developed a tool to ensure learning and educational strategies delivered for students and trainees, in order to promote and acquire pedagogical processes in a successful way.

a. Description and Outcomes

Learning Roadmaps tend to be a tool to be easily integrated in e-learning platforms, in order to stimulate the pedagogical and learning process. It acts upon two fundamental axes: education and learning.

This tool, as used by teachers, supports the management and organization of disciplines and modules, pro-active didactics and pedagogical issues, curricular structures and learning contents, related to competences and skills profiles of target audiences.

For students, Learning Roadmaps primary goal is to assist knowledge construction and stimulate autonomous study, through making available means to search, to analyze, comprehend, organize, and to value learning materials.

Although it is not, at the present moment, the main purpose of this project, Learning Roadmaps intend to contribute for the development of an embryonic system for training profile and acquired competences. This objective, as mentioned earlier, reflects an effort that is currently being made in several contexts in order to value formal and non-formal competences and the growing need to promote lifelong learning activities.
b. Architecture

Learning Roadmaps Tool (Fig. 1) enables the creation of learning pathways making use of a set of metadata, contents, tools and plugins and its association in one entity that congregates all in one learning strategy and process.

![Learning Roadmaps Tool Architecture](image)

Figure 1. Learning Roadmaps Tool Architecture

The Learning Roadmap Manager has two user’s profiles: coordinator and tutor. The coordinator has permission for edition and management of the course guide and other relevant general information and data. Tutors can create, edit and manage, learning actions, modules, units and other relevant associated information, such as sequences, pedagogical marks, events, activities, etc.

Students will be presented with the result of the Learning Roadmap creation for visualization and use.

c. Main Features

The application is built according to usability guidelines, taking into account the main accepted standards for Human Computer Interaction (HCI).

Its main features, besides creating SCORM 1.2 compliant contents, include the following:

- Course Management - Feature responsible for course creation and management, including the definition and time of learning actions, learning guide, outcomes, typology, etc.
- Learning Actions Management - Learning actions management, including. Enables the edition of data on the Learning Roadmap, and management of
modules, units and sequences. This feature defines and manages the learning outcomes, actions resume and typologies.

- Pedagogical Activities Management - Manages pedagogical activities and their associations to modules and units. Enables the insertion of pedagogical marks and associations to data, as also the edition of data on the Learning Roadmap.

Creating a learning roadmap is an easy task in terms of its conception because most of our metadata components are already created and edited: courses, structures and learning objects. Thus, the conception of a learning roadmap is the conception of a ‘tutor suggested’ pedagogical strategy, which involves, primarily, the congregation of reusable data and metadata associated with pedagogical and learning marks (activities, events, exercises, lectures, etc.), sorted in tutor defined sequence for achieving knowledge. Next figure (Fig. 2) presents the flow of events and data needed for creating a learning roadmap.

![Learning Roadmap workflow](image)

**Figure 2.** Learning Roadmap workflow
The application for creating learning roadmaps tends to be simple, and small data is inserted in database because most of metadata is already there. Tutors need to plan what they want to do to power learning and map it in the application. Basically, a strategy needs to be defined, without needing to be adjusted to specific e-learning platforms.

The process is simple: tutors select action type, sequence order, associate course structure components, learning objects and other data. After inserting another pedagogical/learning mark, the system is smart enough to rearrange sequence of marks according to its previous sequence with new or edited pedagogical marks. Also, the type of actions should be defined anytime because the application is dynamic and scalable. System should support several pedagogical actions and activities like events, exercises, lectures, etc, but others can be incorporated anytime as well.

The following section focus on a fundamental part of Trilho Project: Learning Object Manager (GOA). GOA was developed as a tool to assist teachers and trainers to create, organize and manage learning materials according to a competence profile, and also support knowledge acquisition and upgrading1.

III. Trilho Learning Object Manager

Trilho Learning Object Manager (GOA) is a standalone Windows application whose primary purpose is to create standardized pedagogical contents through the aggregation and standardization of instructional resources in several formats. These contents can be further used on a Learning Management System (LMS) that supports SCORM 1.2 standards, thus ensuring their reusability.

a. System Architecture

Trilho GOA is built on the .Net Framework 2.0, using Windows Forms. The published contents are located on the user’s local file system and compressed in a ready-to-use zip archive (Fig. 3). It is a “what you see is what you get” tool, where the user builds the content while seeing it in its final aspect.

b. Main Features

The application is built according to usability guidelines, taking into account the main accepted standards for Human Computer Interaction (HCI).

1 GOA is currently being tested at University of Aveiro (namely in post-secondary education programmes), and in life-long training at PT-Inovação.
Its main features, besides creating SCORM 1.2 compliant contents, include the following:

- **Navigational Management** – management of the content navigation tree: modules, units and learning sequences;
- **Resources Management** – management of the instructional resources from which the project is developed;
- **Content Construction** – construction and view of the content while it’s being built; selection of different layouts and graphic templates; insertion and viewing of resources in several formats; creation of a glossary; previewing of the content in a browser window;
- **Saving** – allows the user to save the content of the page that is being built.
- **SCORM settings** – insertion and edition of SCORM 1.2 metadata;
- **Publishing** – exporting of the project in its final format, ready to import into a LMS.

c. **Pedagogical Advantages**

The contents created via Trilho GOA are pedagogically oriented and are geared towards a smooth learning experience.
The existence of a glossary, different usable templates and content layouts, the ability to import video, sounds, images, text, Flash applets and PowerPoint slideshows, ensure that the content enable a diversified and compelling learning environment.

IV. A competence-based approach

Competence is the ability to perform an action, knowing what to do and when, and implicates selecting, combining and mobilizing resources [3].

The implementation of learning roadmaps concerning skills frameworks enables objective learning outcomes evaluation. Therefore is possible to know which competences are effectively developed by students. Another benefit of competence-based roadmaps is the promotion of autonomous learning and personal knowledge construction, so important to adults learning.

Trilho developed a specific methodology (Fig. 4) to support learning materials elaboration, based on competences.

Competences are determined by the demands of a profession, and can be described, according to our point of view, as behavioral (knowing to be in contexts), communicational (literacy, numeracy) and technical (know-what: theoretic and specific knowledge; and know-how: applied knowledge). These competences require knowledge, formally or informally acquired. In formal acquisition, courses are organized in disciplines and/or modules, according to a specific learning framework and including specific courseware.

Analyzing this cycle, a professional profile described by competences is extremely important to the development of learning objects.

a. GOA’s competence-based structure

As previously referred, GOA’s Navigational Management includes modules, units and learning sequences (composed by pages).

There is a matching between “competence” and “learning object”. Learning objects are auto-sufficient, context independent, in order to be included in databases, matched with other learning objects, and delivered in specific learning contexts responding to learners needs.

Learning objects include well defined objectives, learning activities to perform and evaluation standards.

Example: “Students should be able to (action verb) + learning activity + performance standards”.

With Trilho each learning object, designed with GOA’s tool, is prepared to promote competences development according to a chosen profile.

As previously mentioned, in Trilho’s design (Table 2) a correlation between competence-based curricula design [4] is present.
Figure 4. Trilho Competence Methodology

Competence unities (GOA’s Unity) groups learning objects (which are presented in GOA’s pages), and modules are composed by competence unities pedagogically related.

Table 2. Terminology correlation

<table>
<thead>
<tr>
<th>Competence-based curricula design</th>
<th>Trilho</th>
</tr>
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<tbody>
<tr>
<td>Module</td>
<td>Module</td>
</tr>
<tr>
<td>Competence unity</td>
<td>Unity</td>
</tr>
<tr>
<td>Competence element</td>
<td>Page</td>
</tr>
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</table>

With the above presented modular structure, GOA aims to promote competence development in learning settings, assisting the construction of multimedia learning contents by teachers not familiarized with programming.
V. Conclusions

A framework for the design and implementation of learning objects using a competence-based approach has been presented. This framework was illustrated by the development of a standalone Windows application (Trilho GOA) whose primary purpose is to create standardized pedagogical contents through the aggregation and standardization of instructional resources in several formats that can be used later on a Learning Management System (LMS) supporting SCORM 1.2. The paper includes a brief introduction to the developed software, its system architecture, main features and several pedagogical advantages for its users.

This work is set in the context of e-learning strategies designed for learners that have to be autonomous in most of their learning process, a crucial need for the so-called “Knowledge Society”. In fact, the “Knowledge Society” creates more than never, the need for constantly developing and upgrading knowledge, skills and abilities in order to face labour market demands and changes. This also poses enormous challenges to training programs that increasingly must address competence-based curricula.

References