Teaching Computer Science in Higher Education: Enabling Learning Roadmaps for post secondary courses

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Abstract - **This paper tends to present how eLearning strategies and policies used, in a Portuguese district (Aveiro), are enhancing learning and knowledge for heterogeneous audiences with constraints that are beyond the usual. Besides time to learn and physical distance, they face new challenges like, the need to get specialized in areas where economy is growing; where companies need to adapt to new markets; where the technology revolution is a priority. Experience achieved tells the professionals observed have shown great interest in eLearning actions and for a hybrid methodology. By a simple empirical evaluation, professionals agree that information and communication technologies (ICT) are, in fact, very helpful for those who have several constraints to learn. The use of Learning Management Systems (LMS) tends to accomplish the learning assessments and skills, although there are a lot of improvements that can be done through ICT, especially to promote self-study. The paper presents experiences done with a new learning application that enables a more intelligent and friendly content organization and promotes actor's participation powering efficient learning.**

Index Terms – eLearning 2.0, Pedagogy, Strategies, Paradigm, Platform, Learning Roadmaps.

MOTIVATION

The industrial landscape of large regions of Western Europe is changing at a very fast pace. The immediate consequences are that many industrial regions of Western Europe see their traditional industrial sectors plunged into profound crisis and, in many cases, in total collapse. Acquired professional skills, that in the past were a sufficient guarantee for life-long employability, are becoming in many cases obsolete. The struggle for new jobs or for the survival of the existing ones imposes the need for new skills, new qualifications and new knowledge. This is not an easy task for someone that no longer has its time devoted to being a student or a trainee [1].

This reality poses new challenges to the labor force. Acquired professional skills, that in the past were a sufficient guarantee for life-long employability, are becoming in many cases obsolete. The struggle for new jobs or for the survival of the existing ones imposes the need for new skills, new qualifications and new knowledge. This is not an easy task for someone that no longer has its time devoted to being a student or a trainee. Very likely these persons will be fighting to keep their jobs or have just started a new one. They will not have the time to return to the school, attend normal classes and restart a new learning path.

INTRODUCTION

In an age of fast changes, flexibility of competences and permanent retraining of human resources are valuable instruments for workers and organizations. Life-long learning acquires a strategic importance to innovation and competition, recognized by the increasing number of initiatives to promote professional training and to combat school abandon.

With the evolution of distance education and training platforms, new opportunities were generated for adult and lifelong education, offering flexibility of time and space workers didn't have in formal education. These new methods, supported in technological systems, allow a more customized and personalized education.

Conscious of the potential of eLearning in adult education, Aveiro Norte Program and School of Design, Management and Production Technologies Aveiro Norte, in collaboration with regional companies from the north of Aveiro's district and with the support of regional associations and economic entities, developed a new adult course model - the Specialization Course.

Achieved experience tells that the observed professionals have shown great interest in this training action that stands for a hybrid methodology. By a simple empirical evaluation, professionals agree that technologies are, in fact, very helpful for those who have several constraints to learn. They use the LMS in order to accomplish the learning assessments and skills but they also feel that there are a lot of improvements that can be done through ICT, especially to promote self-study. Rather than repositories, more intelligent and friendly content organization and actor's participation could enable a more efficient learning.

In order to clarify which the types of actors enrolled in this challenge are, and according to the new arising strategies referred above, are next described the most common learning profiles that nowadays look for training and learning at the University of Aveiro.

STUDENT PROFILES

I. Workers

The most significant job offer in Portugal comes from small and medium enterprises where the training system from the University of Aveiro is in general more requested. Workers find training and learning in order to improve their skills at work, due to technological and organizational changes at work. Nevertheless, these workers don't usually have much spare time to learn in spite of their high motivation, and frequently happened problems at work where their physical presence is needed. Related with these circumstances, absence rates of workers are significant although it doesn't reflect lack of interest on the part of the workers.

In such cases, it is faced a new reality where the traditional and conventional definitions of 'absenteeism' and 'participation' may be different from the ones applied to fulltime students. Learning outside the classes, at home, at work, on the trip to home or work, are some of the new realities that urge the realization of new learning and training models, where new instruments to support and help the teaching and learning processes are essential.

II. Unemployed

There are two types of unemployed people who search for training and learning. The ones who have already worked and, due to several reasons, want to start studying again to get better opportunities by enrolling in specialized training in areas where the economy is growing. The other group of unemployed is of people who are trying to search for the first occupation. Usually these students are looking for training in order to get skills and specialization to enter soon in the labor market. Usually, unemployed seek for the Technological Specialization Courses.

III. Continuing students

The last common learning group are the regular students, who ended high-school and want to choose one the following tracks: to get a Technological and Specialization Diploma, enabling short-term access to the labor market; or an undergraduate course, entering later on in the work market.

TECHNOLOGICAL SPECIALIZATION COURSES

As a result of an exercise of identification of training needs, carried out by a task force including enterprises, associations, local governments and other local educational and training partners, the University of Aveiro took the challenge of promoting the creation, accreditation and conduction of Technological Specialization Courses (CET).

A CET is a post-secondary training that aims to confer a Level IV professional *qualification*. This is obtained through a combination of secondary education, general or professional, with a post-secondary technical training, and is characterized by being a high-level technical training, resulting in a qualification that includes knowledge and skills at higher education level. CET allows the acquisition of skills and knowledge which, by taking them on a generally autonomous or independently, responsibilities of design and or management.

The CET are learning and training courses, with an average of 1500 hours in "on class training", supplemented by "training in work context". The "training in work context" has duration of 540 hours, occurring in several enterprises across the Aveiro district. Without prejudice to the primary objective of immediate employability in the labor market, it allows the continuation of studies in undergraduate courses at the University of Aveiro and their Polytechnic Schools.

The training plan of a CET is divided in three main components: *general and scientific training*; *technological training* and *training in work context*:

The main goals of the General and Scientific Training component are to develop attitudes and behaviors appropriate for professionals with high level of professional qualification and adaptability to the work and enterprise. Also, it aims to enhance where this is essential, knowledge of the areas of scientific underlying technologies of their own area of training.

Technological Training component seeks to understand the practical activities related to the fields of technological nature and troubleshooting the scope of professional practice.

The Training in Work Context looks at the application of knowledge and skills acquired to the activities of their professional practices. Also, it intends to implement activities under supervision, using the techniques, equipment and materials that are included in the production of goods or services.

The successful conclusion of a CET confers to the student a Technological Specialization Diploma (DET), giving access for a Level IV Professional Capability Certificate, recognized in the European Union space. Also the DET confers for students, the crediting for continuation of studies in undergraduate courses between 4 and 30 ECTS (European Credit Transfer and Accumulation System) at the University of Aveiro.

TECHNOLOGY AND PROGRAMMING OF INFORMATION SYSTEMS CET (CET TPSI)

I. Description

In operation since 2003 in several cities of the Aveiro district like Ovar, Espinho and Oliveira de Azeméis, with daytime and post-labor schedules, the CET TPSI has trained about 100 students, divided by classes of 20 students. The feedback from industries where students perform the internship has been very positive, promoting the

dissemination of these courses around the region of the district and contributing for improvements in new editions. When a CET ends all its training components, a study is made to evaluate the labor market in order to avoid market saturation in specific training areas. Should the study show signs of market saturation, the course location is changed to another area of the district.

II. Goals

To increase the supply in the labor market of professionals with a high level of technical expertise in the various activities related to programming, particular with sufficient skills to meet the challenges that new technologies pose to businesses in a increasingly competitive society.

The initial technical training begins with mathematical concepts that provide the foundation for a good understanding of the logic and techniques behind the programming.

It is given a special emphasis on the design of algorithms and the entire structure of logical thought. Next, are then addressed different programming languages. They are intended to address always in a logical way, putting less focus on the syntax and features of the environment in language development. The aim is to enable trainees to move quickly from one language to another facilitating adaptation to development tools that are used in the company.

Finally, a project is run where the trainee builds up skills on the taught knowledge.

Table I presents the current structure of CET TPSI. The CET TPSI is divided into 3 learning areas or training components: general and scientific training; technological training and training in work context:

TABLE I
CET TPSI CURRICULAR STRUCTURE

Training component	Training unit	Hours	ECTS
General and Scientific Training	Economic and Social Culture	36	2
	Portuguese Communication and Expression Techniques	46	3
	English Communication and Expression Techniques	46	3
Sum of General and Scientific Training		**128**	**8**
Technological Training	Algorithms	70	5
	Systems and Database Analisys	110	8
	Network and Computer Systems Architecture	60	4
	Ergonomics and Authoring Tools	60	4
	Programming Languages	90	6
	Computational Methods and Statistics	70	5
	Programming and Web Services	110	8
	Computer Security	52	4
	Information Systems Project	110	8
Sum of Technological Training		**732**	**52**
Training in Work Context	Training in Work Context	540	20
sum of CET		**1400**	**80**

III. On-field training strategies

During the training in classroom, every subject, theme, issue is always around information systems. So, usually, depending on the amount of learning information and knowledge that is intend to be achieved by the students, the learning strategies are organized in the form of small piece of learning units that must be accomplished by the students in the form of learning marks or milestones. Students must fulfill the goals of each learning mark in order to step forward to the next outcome to be achieved. In the end, students should be able to apply the knowledge and training they have been submitted to, in order to use it in their future professional activities. This methodology and class philosophy has been followed since 2003. From 2003 to 2007 this methodology was improved by the introduction of standalone tutorials in the form of learning roadmaps. From earlier 2007 it has been developed a web based platform with the aim of supporting online those learning roadmaps. The main reason for this was that standalone learning roadmaps were content static, i.e., after being created, to update or upgrade them it was need to edit everything again and next, deploy it to students. Imagine classes were you are presenting emergent technologies, programming techniques or standard recommendations. During the classes, some students may suggest important referenced sources about thematic you are lecturing and that might be important. Moreover, students, guided by the default module curricula may want to follow the module structure, i.e., they may want to know were the learning mark or milestone is indexed within the module structure. Following this methodology the web platform was progressively developed to accommodate those features. From that time, the learning roadmaps concept has been central to the followed learning strategy methodology.

LEARNING ROADMAPS FOR HIGHER EDUCATION

To proceed with Learning Roadmaps explanation, it is important to clarify and specify what the meaning of a Learning Roadmap is.

I. Learning Roadmap Definition

Some authors, like Clement [2], states that *the chosen route, taken by a learner through a range of eLearning activities, allows them to build knowledge progressively, moving the control of choice from the tutor to the learner*. Also, Jih [3] Jih contends that the paths of learning are not only beneficial to students, but also allow teachers to monitor and improve student learning.

Having in mind these characterizations, it is proposed the following definition for Learning Roadmap: *Detailed description of the life cycle of a discipline. It comprehends all contents and associated events and activities that conduce to the goal of a thematic issue. Each thematic issue is indexed with each learning mark. A Learning Roadmap aims to promote successful learning and knowledge acquisition, giving the student autonomy and responsibility*

by encouraging the same in the learning process. By induction, a Learning Roadmap tends to be useful to those who teach in order to ensure more effective management and pedagogical organization of the course, letting him diagnose and follow up effectively, student learning.

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

Assuming and promoting the principles of free navigation, Learning Roadmaps is based using the approach of creation supported by knowledge. The system should be able to associate contents, issues and subjects, with different layers of granularity, from simple and small definitions or concepts (reflecting the interest of student for a subject of high specification) to a collection of modules or courses (relevant for a desired thematic).

This granularity is mapped in the creation of learning objects ontology, featuring mechanisms for association, linking and contextualization, capable to catalyze the learning and training processes. The developed platform, Learning Roadmap Studio, has its genesis on the basis of this definition.

II. Learning Roadmap Studio (LRS) Concept.

The core of LRS is focused in the Learning Roadmap definition. The approach to do this is to understand how those technologies work and, giving the present experience with LMS, to achieve what is useful and important to the learning and training process.

These goals aim to compose learning and training roadmaps that acts upon two fundamental axes: education and learning. For teachers and module managers, the learning and training roadmaps aim at becoming a self-supporting tool that stimulates the organization and management of the education materials, as well as a useful functionality and not only another technological innovation framework without advantages for the actors. For students, the learning and training roadmaps aims to promote self-study and supervised study, endowing the pupil with the functionality to find and to perceive the meaning of the study materials, stimulating the pupil to explore those materials.

In the next section are presented the main components that enable a Learning Roadmap: Learning Objects; Modules; Learning Roadmaps.

III. Learning Objects

A learning object (LO) is the smallest learning piece acting as a significant unit [4] [5]. Although its size can vary, a learning object must be mapped for only one unique purpose or concept, independently of the context or any other learning piece, enabling it's reuse, trace and management. Basically, a LO can be seen as a supported MIME-Type content with associated metadata.

Excluding Administrators, all user profiles may add LOs to LRS database. Those LOs may then be public, available to be reusable by others, or private, used only by their creator. When inserting a LO, users must define several data like Name, Description, Outcomes, Skills, URL (in future, embedded URL will be possible) and Private/Public use

IV. Modules

A module is an educational object imparted in a series of lessons, topics or meetings. It can be divided into logic units or parts with a clear organization and structure. LRS requests as main module metadata the fields: Name, Description, Pre-requisites, Target Audience, Outcomes, Skills, Estimated Learning Time and General Activities.

Module Managers (or Course Managers), the ones who create modules, should also define Keywords, for searches, linking and navigation. The module can also be associated with a Thematic Class (or Topic), also to enable better searches and navigation. Each module should have a Tutor assigned to it. Each module should have a content structure, defined by Module Managers. The structure is created regarding to the parent content item, order sequence and a name, description and estimated learning time should be defined.

Module structures are not mandatory for module creation but Module Managers are invited to create them because they may be useful for Tutors index learning marks of learning roadmaps, enriching knowledge that should be achieved or targeted for students.

V. Learning Roadmaps

Only Tutors can create Learning Roadmaps, after being assigned as Tutors by the Module Manager. This means that a Module may have only one Learning Roadmap and that Learning Roadmap cannot be associated with any other module.

A Learning Roadmap is fed by learning marks, which for its part, needs to be created using several components like sequence and order of a learning mark, action type, associated LO (private or public), module structure component, estimated learning time and URL (like LOs). Embedded URL will be possible in future. More learning marks can be added as needed (Figure 1).

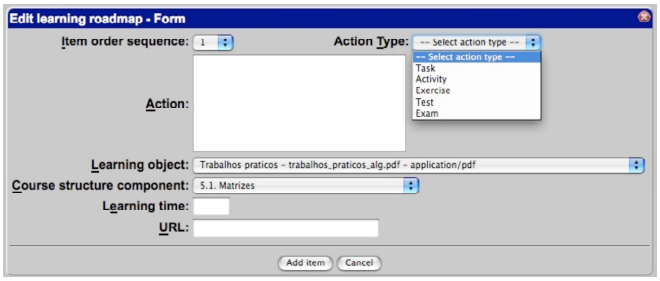

FIGURE 1
LEARNING ROADMAP CREATION

In the end, the complete Learning Roadmap will be available for students subscribed and approved for the

course where the Learning Roadmap was created. Thus, students may use it for achieving knowledge and information, and the learning process tends to be easier, more organized and successful.

VI. LRS towards on promoting eLearning 2.0

Web 2.0 is here today—and yet its vast and disruptive impact is just beginning. More than just the latest technology buzzword, it's a transformative force that's propelling companies across all industries towards a new way of doing business characterized by user participation, openness, and network effects [6].

Web 1.0 was meant to be read-only web, which is content produced by expert authors and published on the web to be read by consumers. The Web 2.0 is defined as the read-write web, i.e., all the services and applications are provided to allow individuals to co-create or add content, collaborate and share it with others. Also, Web 2.0 supports user-generated content, which is created by common "users", rather than specialist authors or publishers using a variety of affordable technologies like blogs, podcasts and wikis, encouraging the social aspect of the Web, like, for example, social bookmarking tools and social networks.

eLearning 1.0 and eLearning 2.0 share the same definitions: While eLearning 1.0 was mainly about delivering content, primarily in the form of online courses and produced by experts, i.e. teachers or subject matter experts, eLearning 2.0 powers the information and knowledge creation and sharing with others like blogs, wikis, social bookmarking and social networks within an educational or training context to support a new collaborative approach to learning.

Based on these definitions, it is assumed in a general context that Web 1.0/eLearning 1.0 is content-oriented and Web 2.0/eLearning 2.0 is people-oriented, often referred to as Social Learning.

The developments made in the applications were made having in mind the following assumptions: Teachers produce the Learning Roadmaps, deploying it in LMS applications; students are then able to edit the teacher's default Learning Roadmaps, adding personal data, which could be used to share it through social learning tools. Figure 2 shows how should be produced and deployed by teachers, allowing edition and information aggregation to feed social and collaborative tools.

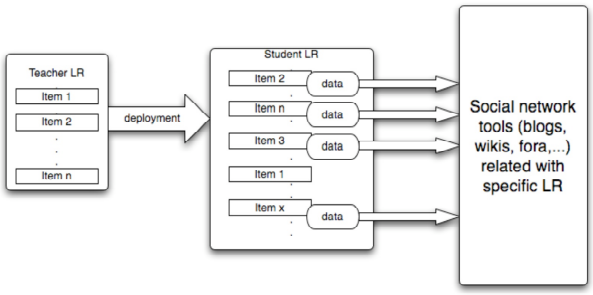

FIGURE 2
ELEARNING 2.0 BASED LEARNING ROADMAP SCHEMA

VII. Platform use and validation (Case Study)

It has been developed a case study for the last on-class module, Information Systems Project, before they went for training in work context. It was intended to ascribe more responsibility and autonomy to students, preparing them for the next stage, where it is desired that acknowledged training they have received will help them on this challenge. For the case study, the learning roadmap was conceived according with the standards and best practices of software engineering. Theoretical issues like reading activities and research tasks were intercalated with practical activities in order to produce results for the individual projects. Students were invited to follow the learning roadmap until the end of the discipline, step by step, i.e., learning mark by learning mark. Later, they were inquired about the relevance of the application to achieve results in the discipline. They referred, the application, and thus the learning roadmap, was useful to guide them during the discipline. It increased efficiency and productivity regarding the work on the project and reduced the number of times that they spend with the teacher to clear doubts or less-relevant questions, powering the time spent with teacher for project supervision and for other more complex issues. Because the application was available for Web environment, it enabled the students to guide themselves outside the learning classes, promoting autonomous work. Also, due to the reutilization of learning contents, students suggested the teacher to create another learning roadmap for the training period, embedding selected contents from the previous discipline. They appreciated the application and felt it would be useful in guidance for the training stage, in order to achieve results in an enterprise-based context. The student's profile of LRS enables the upload of learning objects. It allowed students to upload relevant content for the project and to share it with others. The teacher also included in the learning roadmap some of students uploaded learning objects, feeding the resources of some specific steps or learning marks.

Also, the students suggested several improvements and features for LRS: The application could allow users to track/check steps, learning marks and to insert notations in those items; The application could also enable another learning mark for uploading scheduled deliverables, reports or other relevant work for teacher supervision; It would be interesting if the application could aggregate other collaborative tools like discussion fora or blogs; More intuitive and user-friendly user interface is desired for the system; Exporting tool for learning roadmaps could be useful for students in order to use the learning roadmap as a standalone document, when the Web is not available.

All the suggestions were identified and will be developed in future versions of the application.

CONCLUSIONS

The main contribution of this work is a strategy that facilitates implementation of new methods of teaching and learning, based Learning Roadmaps. Here, again, seeks to highlight the need to find and implement mechanisms to

support individuals and organizations with a view to efficiency in learning, knowledge and skills. It is argued also that these mechanisms must be both adaptable to the needs of the stakeholders, teachers and students, allowing them to adjust or adapt different strategies for different individuals and learning communities.

Another contribution of the work described has been the development of a prototype, LRS, for creation, edition and deployment of learning roadmaps for higher education, which attempt to guide students, congregating several learning components, from the learning process, that compose learning roadmaps, according to the definition presented in this article: courses, structures that compose courses, learning objects and pedagogic and learning marks. The developed prototype encourages students to participate in the learning process, supplying additional tools for personal edition, enabling customization from teacher's strategies to their own learning rhythm and acknowledgement methodologies.

Moreover, it is our assumption that the future of learning, looking for the current learning theories, knowledge construction, policies being made and current social contexts, endorse the development of systems, applications and tools for more and better involvement of all actors inside the learning process, encouraging pro-activity among learning environments.

The contributions are also specific because it has been possible to gather learning and training experience in higher education with emergent theories, concepts and technologies that support new ways of learning and achieve knowledge.

At last, we hope to soon make available, for large-scale use, the prototype in the Web. Although the system is online, it is needed to adjust several technical issues that limited the project, like available bandwidth and physical space enabled by the host, which prevents the growing of contents and users.

Since the first students in CET in 2003, to the graduate students in 2008, five CET TPSI editions were completed, using Learning Roadmaps, from the standalone version to the Web platform. Our experience shows that this methodology, which is being improved day by day, has increased the number of CET students successfully graduated. Also, from enterprises and companies feedback, this methodology allows to prepare students for the software development labor market, increasing productivity, efficiency and goal achievement philosophy or, improving their skills on the job. It has been a conviction of module managers that this strategy empowers the student's autonomy, responsibility, better software tests and quality control, deadlines and goals target philosophy, besides promoting efficient use of ICT, eLearning tools and Internet. Meanwhile, it has been possible to motivate a considerable percentage of students who hadn't in their minds to continue their studies. Currently, is usual after a CET TPSI ending to hear students saying 'I liked being here and I want to proceed my studies in a CET TPSI related undergraduate course'

Finally, it is presented a survey related with the target audience of students, what they do, and the next step taken from the students after ending the course (Table II).

TABLE II
CET TPSI SURVEY FROM 2003 TO 2008

CET TPSI location	CET year	CET Type	No. Students	Workers	Non workers	CET graduation	Working on area	Went for an undergaduate course
Oliveira de Azeméis	2003	Daily	12	2	10	6	5	3
Ovar	2004	post-labor	15	2	13	12	12	6
Oliveira de Azeméis	2005	Daily	20	2	18	16	15	8
Ovar	2006	post-labor	19	19	0	15	14	5
Oliveira de Azeméis	2007	post-labor	19	16	3	17	15	6
Oliveira de Azeméis	2008	post-labor	20	15	5	16	16	7
Sum			**105**	**56**	**49**	**82**	**77**	**35**
%			**100.0%**	**53.3%**	**46.7%**	**78.1%**	**73.3%**	**33.3%**

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