PERFORMANCE-CENTERED ADAPTIVE CURRICULUM FOR EMPLOYMENT NEEDS

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PERFORMANCE-CENTERED ADAPTIVE CURRICULUM FOR EMPLOYMENT NEEDS

Abstract

In the present knowledge economy the ability to learn in a way that produces knowledge and practical insights is vital. The technology evolution has also radically changed today's educational and labor market. The Small and Medium-sized Enterprises (SMEs) across the Information and Communication Technologies (ICT) and Telecommunication Industries in Europe face growing shortages of highly skilled workers in multiple areas of engineering and information technology who have the knowledge to take full advantage of what continually evolving technology has to offer and thus to ensure that their companies will stay competitive on the market. For this reason, Plovdiv University (Bulgaria) and the Spanish University for Distance Education UNED, along with several enterprises are working in the PAC project, which has been funded with support from the European Commission.

1. Introduction

Universities, business and the employment world in general face continuous changes and needs of the today's knowledge-based society, a society based on learning to learn to be able to address emerging developments in an ever-changing environment, where work areas evolve quickly and forcing employees to keep up-to-date in a continuous process of adaptation. In this context, educational institutions need to understand and promote the transformation of these changes, discovering in them the true meaning to strike the balance between what we think is desirable to learn and what is convenient or practical.

Under these circumstances, Universities face new challenges; they must prepare its students by providing a basis for a training that meets new demand requirements of the employment world today, which is as volatile as it has ever been [1]. That is the reason why it is imperative to identify new emerging profiles that are able to cope with the new needs generated by the today's knowledge-based society. Achieving this requires a shift in Universities thinking to know the skills and competencies that enable students to adapt to the new times to tailor their studies to their future plans within a curriculum framework [2].

In this paper we present a new project called PAC (Performance-Adaptive Curriculum for Employment Needs) that was conceived with the idea of contributing to the design of programmes which incorporate new qualifications, mainly at Master's degree level. The main goal pursued is to identify new requirements and skills needed to acquire new competences in technical areas such as software engineering, control systems or electronics.

2. Today's knowledge-based society

To enhance the economic and today employment, where technology is advancing by leaps and bounds and permeate all levels of an organization, training of workers is directly linked to their workplace. Companies need to carry out an analysis of the professional profiles to accomplish a series of changes which require organizing work and formation training programmes jointly. To achieve this we should consider training activities in the short, medium and long terms, becoming dynamic and active, solid, well structured, consensual, appropriately planned and systematic training.

That is the only way to contribute to ensuring higher productivity, competitiveness and economic growth. Companies need highly qualified workers who are capable of responding to new challenges, not only in terms of formal qualifications, but also in terms of practical skills and competences acquired through training [3].

In the light of what we have just said, training is a key factor in today's knowledge-based society. There is a need for further training in a continuous recycling process; workers must constantly be able to learn, ensuring solid practical knowledge [4]. In this sense, PAC project has been designed to contribute to the changes our society demands related to learning processes:

- Students must be considered as the leading actors in the construction of their knowledge: The training plan created in PAC project has been designed taking into account the views of students.
- Greater autonomy, activity and responsibility of students should be promoted. The training plan created in PAC project has been designed to encourage engineers to take on responsibilities, and subsequently be capable of taking decisions and solving problems in their workplaces.
- Stimulate the observation and analysis as driving forces for change.
- Building bridges between theory and practice. Students need help in learning processes closer to the workplace than traditional educational environments, ensuring functional convenience.
- Sociocognitive approach to the learning process. People learn through interactions with others in both teaching-learning situations and work. The training plan created in PAC project has been designed to foster student interaction through the use of various tools in high quality virtual environments, enhancing cooperative group work.
- Training has to be considered as a lifelong process. The PAC project contributes to university curriculums, since the designed training plan can be incorporated to both regulated studies at Undergraduate and Master degree levels. Moreover, it could also be useful for non-regulated studies.
- Another factor to consider is globalization, which has to be understood not only in market and economic aspects, but also in a broader educational aspect. Education and training strategies need to be agreed among different EU countries, enhancing mobility of students and workers on the global labor market [5]. Thus the PAC project is being developed in a consortium of different institutions and companies belonging to three European countries.
- Learning to learn must be the new motto, since students are required to learn continuously to keep their skills and professional competences updated [6]. In PAC

project, different strategies have been developed in order to encourage students to become their own teachers and develop independent learning skills.

- Training has to be a systematic process [7]. The PAC project has followed a defined sequence of steps that starts with a needs analysis which help in the setting of concrete objectives at general and specific levels, and ends with a global evaluation.

3. Description of Performance-centered Adaptive Curriculum for Employment Needs Project

The aim of the PAC project is to develop adaptive to business and employment needs curriculum on master degree level, applying performance support systems concept and principles for education in performance-centered content management learning system.

The PAC workflow model is based on recent research on design and development of performance support learning and is in line with the Rational-Linear approach [8]. The model consists of several stepwise building blocks:

- Reference situation. The content of the curriculum is determined by the referent situation, that is, the (work) situation in which students who are enrolled in the curriculum will apply their knowledge, skills, and attitudes after graduation. It is necessary to determine the most important situations students will later encounter in their profession for which they should be trained during education, as well as the competences that are needed to act successfully in these situations.
- Learning objectives. Objectives are short but clear statements about the specific outcomes that are expected from students and specify the behavior that will serve as evidence that the learning goal has been achieved.
- Performance support instructional strategy. It describes how students can be supported in developing their skills, knowledge and attitude by instructional design.
- Performance assessment. In order to evaluate whether students have developed their competences to a sufficient level, an authentic assessment has to be carried out. The summative evaluation of students' competences refers to formal testing of what has been learned in order to formulate a grade or mark.

There is a more detailed explanation of these items contained in the "Defining the Training Plan" section below.

4. General context of the PAC project

Universities must be able to acquire a full understanding of actual marketplace needs in emerging areas and offer just-in-time and just-enough flexible learning, uniquely tailored to the need of the learner and his job role [9].

We can say that many of the existing learning systems fail to achieve their aims because of three main reasons:

- They do not do a good job in capturing the demand of new knowledge and in creating and updating corresponding courses and study programs.
- The learning does not always result in practical insights that can make a difference in real work situations.
- They do not manage to adapt their programs to a broader target age group (lifelong learning), and try to attract employed students, which come from companies.

In order to respond to this shift from the mass education and remain competitive, the universities are trying to adopt this 'needs-driven' learning approach and implement learning systems that are aware of the problems and provide means through which they can be overcome [10]. Vital parts of these systems are the employer-academic partnership activities on a regional, international and sectorial basis.

The PAC project has been created upon the following preliminary background analysis findings:

a) The latest researches prove that the successful cooperation of Higher Education Institutions (HEIs) in synergetic relationships with businesses is getting critically important, becoming the ideal driver of knowledge-based economies.

   The project aims to establish a stable Europe-wide, knowledge transfer system between HEIs and enterprises positioned in Engineering, ICT and Telecom industries, to ensure exchange of field-based experiences and constant flow of theoretical knowledge, organize around business and learners needs.

b) The demand for highly skilled workers who have the knowledge to take full advantage of what continually evolving technology has to offer is increasing. Universities therefore should offer courses that address the actual marketplace needs in cutting-edge areas such as Engineering, Information and Communication Technologies (ICT) and Telecom services.

   The project will provide a collaborative, open and innovation platform that will facilitate interaction between academics and business professionals. Educational contents will be structured in modules that will provide just-in-time, just enough and at the point of need support to learners.

c) In order to obtain sustainable economic growth and employment creation the European Union recommends focus on sectors such as Engineering, Information and Communication Technologies (ICT) and Telecom services [11].

   The project is aiming at the service sectors as they will have the best prospects, with around seven million additional job openings being created between 2010 and 2020. Recent studies predict that the gradual shift in Europe away from the primary sector and traditional manufacturing industries towards services (including Engineering, Information and Communication Technologies (ICT) and Telecom services) and the knowledge-intensive economy is likely to continue. By the year 2020, almost three quarters of the jobs in the EU-25 are expected to be in services.

d) The project follows the Europe 2020, the European Union's (EU) growth strategy for the coming decade [12], and the higher education modernization agenda, in which Europe is embracing the need to create a more connected and functioning relationship between Government, business and Higher Education Institutions (HEIs) in order to increase employment, productivity and social cohesion.

Once the training plan are finished and instructors have completed the master degree programs, there will be a pilot experience with actual students next semester in 2013, that will contribute to exam the efficacy of the learning strategy used in the project. The form according to which the training will take place will be mainly on line, supervised by the two University partners. However, there will be face-to-face practices at the enterprise partners, what will upgrade knowledge, skills and attitudes of students, providing them exposure to international expertise.

5. The PAC project consortium

Although a broad range of support mechanisms are already in place, they are often build on a too simplistic picture of the worlds of business and higher education and therefore fit only a relatively small proportion of potential collaborations. The partnership of the PAC project has accumulated enough experience in the field of the project to become a knowledge partnership in the field of jobs role recognition, skills, knowledge and competence identification and connected courses implementation, to the end point in the process – professional certification. All of them implement a set of required steps to achieve success and to ensure exchange of field-based experiences and constant flow of theoretical knowledge, organize around business and learners needs.

Following there is a description of the PAC Project partners:

- Plovdiv University 'Paisii Hilendarski' (PU) - Project coordinator – Bulgaria

  PU is created in 1961 as a teacher education institute and in 1972 developed into Plovdiv University. Today PU is the largest humanitarian higher educational and research establishment in South Bulgaria. PU is an independent government-funded institution that delivers degrees on most disciplines including Computer Science and Information Technology, Physics, Chemistry, Mathematics, Humanities, Arts and Letters. Currently, over 15 thousand students are studying on degree programmes at 13 Faculties and the University has more than 1500 lectures.

- INDEX-6 Ltd. – Bulgaria

  INDEX-6 was established in 1990 by a small group of engineers – experts in the areas of mechanics, hardware and software, with significant experience in automation and robotics. The main activity of the company is manufacturing of machines for the food industry. After the year 2000, INDEX-6 introduces its highly technological Ultra Clean equipment for bottling of ESL microbiologically sensitive products in clean environment. The company offers engineering and execution of complex technological lines with integrated logistics solutions, detailed process monitoring and control, which situates the INDEX-6 conception among the best manufacturers of such equipment. Nowadays, INDEX-6 possesses the contemporary technology and production base for manufacturing high quality equipment that has earned its place on the world markets.

- TEPOLSoftS Ltd. – Bulgaria

  TEPOLSoftS works in the field of computer technologies. Its main task is the development of performance-centered learning systems, which can be used in high-level education, as well as in corporate training practices. Nowadays technologies take a big part in our life, but still very few organisations use them as

a main tool for education. The solutions developed by TEPOLSoftS offer interactive, easy to use and modern way for training. A specially developed methodology and personalized approach make our systems highly productive and cost-effective. Developers working at TEPOLSoftS are with long experience in software development and server administration. They have worked on several projects in the field of e- and m-Learning.

- Adaptive Predictive Expert Control (ADEX) S. L. – Spain

  The principal activity of ADEX is the optimization of industrial processes using software based on an internationally patented methodology, culmination of 30 years of research and development, and eponymous with the company name. This methodology offers a real alternative to conventional PID control, overcomes its principal limitations and opens Adaptive Optimized Control for industry. Since 2005, the company has developed a software platform called ADEX COP (Control and Optimization Platform) which provides a means of systematically developing and implementing specific strategies incorporating ADEX controllers for optimized control applications. ADEX systems are always the result of applied research projects. Examples of processes which can often be improved in terms of performance and operation using ADEX control are separation, distillation, purification, blending, fermentation, combustion, milling, navigation systems, autopilots, dynamic positioning, particle accelerators, reactors etc. The company is currently participating in several national and EU FP7 projects.

- Electrical and Computer Engineering Department (DIEEC) of the Spanish University for Distance Education (UNED) – Spain

  The Electrical and Computer Engineering Department (DIEEC) of the Spanish University for Distance Education (UNED) gather research staff of four different areas: Electrical Engineering, Electronics Technology, Telematics Engineering and Systems and Control Engineering, as well as relations with Computer Science and Engineering. DIEEC teaches subjects in grade, post-grade and PhD levels, this work is closely related with the main research activities of the department in Electric, Electronics and Control Engineering. Also it is very relevant the research related with the blended nature of the methodology used for learning at UNED. With more than20 years of research and implementation experiences, DIEEC keep researching in emerging technologies to provide new facilities to integrate different techniques for acquiring practical competences through distance education methodologies.

  These researches in different fields have been related from the beginning of the department with a close relationship with private companies, as well as with different institutions and organization, as the IEEE (Institute of Electrical and Electronics Engineers) and other organizations, like IFAC (International Federation of Automatic Control), ACM (Association of Computing Machinery) or ASEE (American Society of Engineering Education).

- International Software Consulting Network GesmbH – Austria

  ISCN was founded in 1994 in Ireland. It is an Irish SME with software development offices in Austria, with a private company ISCN Regionalstelle founded in 1997, and I.S.C.N. GesmbH founded in 2001 in Graz. ISCN is an accredited Intacs and VDA (Verband der Automobilindustrie) training provider for ISO15504 and Automotive SPICE and one of the leading consulting and training

organisations in the field of Software Process Improvement, with customers from Continental AG as the second largest automotive supplier in the world (ca. 140000 employees), ZF Friedrichhafen AG the third-largest German automotive supplier, and among the 15 largest companies in the world automotive supplier rankings. ISCN was the coordinator of the LLP network EQN (European Quality Network) which led to the foundation of the European Certification and Qualification Association. In 18 countries in Europe industry training follows now defined quality rules and certification processes. ISCN is still the technical manager of the ECQA platform and executive board member. ISCN experts are actively involved in the numerous ECQA certified job role committees, defining the skills and needs for several professions; moreover, ISCN is an accredited ECQA training provider offers trainings for different professions.

6. Defining the Training Plan

The Training Plan consists of a sequence of activities to support instructors in designing PAC curricula. The format of the model is based on recent research on design and development of performance support learning. The learning strategy tries to resemble task analysis, work modelling, use-case modelling and process map, used in other domains such as software engineering design and healthcare [13]. The PAC workflow model is in line with the Rational-Linear approach, which represents one of the strongest traditions in the curriculum development. In addition, the PAC workflow model reflects research on instructional development models.

A summary of the actions initiated at the PAC project according to the proposed model is featured below.

6.1 Reference Situation

The content of the curriculum should be determined by the referent situation; that is the work situation in which students who are enrolled in the curriculum will apply their knowledge, skills, and attitudes after graduation. There can be several referent situations students should be trained for [14]. It is essential to determine the most important situations students will later encounter in their profession for which they should be trained during education.

In order to elaborate the reference situation a number of practical questions have been raised concerning professional scenarios. An example of the guiding questions to indicate the referent situation can be: what situations will my students most likely encounter in their later profession? Or, what are the main referent situations?

After the referent situations have been determined, the competences that are needed to act successfully in these situations are determined. A competency can be defined as the capability to apply or use a set of related knowledge, skills, and abilities required to successfully perform "critical work functions". For each of the main referent situation a set of competences should be defined through a number of guiding questions. An example of that kind of questions can be: what knowledge does one need to perform successfully in this situation? Or, what skills does one need to perform successfully in this situation?

At that point it is possible to create a competence map, a graphical representation of all competences involved in the referent situations, indicating what competences should be trained during education. In the competence map the relationship between the competences is indicated, so it becomes clear what competences should be developed first, which should be developed later and which are part of others.

The last point in the Reference Situation phase is the elaboration of the learning goals. The learning goals describe the general educational aims of the learning program; what will the student learn in order to prepare him for his later profession. Knowing where you want to end up is the first critical step in not ending up someplace else.

It is recommended to consider a range of cognitive skills when developing goals. In this sense, the curriculum learning goals should go beyond simple knowledge recall and should include more complex cognitive skills such as analysis, synthesis, and evaluation and higher-order skills such as organising, critical thinking. In order to formulate learning goals a number of practical questions have been raised. An example of the guiding questions can be: what will the students learn during this curriculum? Or, what skills, knowledge, attitudes are at the centre of the curriculum?

6.2 Learning objectives

After the learning goals and referent situation have been defined, we can start to define the learning objectives. The main difference between learning goals and learning objectives is the level of specificity. Objectives are short but clear statements about the specific outcomes that are expected from students. For assessment to be effective, objectives must be clearly articulated before deciding upon methods and measures [15]. Objectives should specify the behaviour that will serve as evidence that the learning goal has been achieved.

The learning objectives are described in terms of what skills, knowledge and attitudes are to be shown by the student and in what kind of context. In the description of the learning objective it is stated first of all, what behaviour should be shown, secondly, under what conditions the behaviour should be shown, including what tools or assistance is to be provided and, thirdly, what standards or criteria apply for acceptable performance.

It is also important to consider that the formulation of the behaviour that should be shown consists of measurable or observable verbs. More appropriate verbs are those that describe the behaviour that results from correct use of knowledge, skills and attitudes. Examples of such verbs are: to describe, to solve, to compare, to define and to list.

When describing the conditions under which the behaviour should be shown, all aids and restrictions that influence performance of the task in the referent situation should be included [16]. However, when describing the performance criteria or standards, you might provide the lower limit of performance stability. The performance stability is a statement of the number of opportunities the student gets to perform the terminal behaviour and the number of times his performance has to reach or exceed the standard. Write a number of chances student will be given to demonstrate that s/he has achieved the objective. Write proportion of time student must succeed. The performance stability limit should be the same ratio of successes to opportunities as the student is likely to have in the referent situation. Set the performance stability high if the student performance is critical.

In order to define learning objectives a number of practical questions have been raised. An example of the guiding questions can be: what behaviour do I want the student to show in order for me to know that he has sufficiently developed his competency? Or under what conditions should the student be able to show this behavior?

6.3 Performance support instructional strategy

After the learning objectives have been defined, the learning tasks can be developed in order to help students achieve these learning objectives. In the face of the instructional design learning tasks can take many forms. In this section general guidelines are provided on the design of these learning tasks and not on the domain specific content of these tasks. It is described how students can be supported in developing their skills, knowledge and attitude by instructional design.

It is now vitally important to use authentic tasks and confront students with a problem situation resembling as much real-life working situations as possible. It could be either a real case or a computer-based simulation. It may be helpful the following guiding question: what problem situation will the student encounter in the later profession?

The use of gradual increase of complexity is strongly recommended [17], it can be addressed by designing a sequence of performance tasks which students need to go through in order to solve a real-life problem or perform a certain task in the referent situation. Ideally, these tasks are grouped into classes of tasks, ordered from simple to complex. It is also recommended to provide variability of individual learning tasks to increase learning transfer. Through the variability in learning tasks, students are better prepared for the variations of situations they will encounter in real-life work. A typical guiding question could be what kind of variations while students encounter in their profession?

If a routine task is a prerequisite for a set of more complex activities, students should be provided with a training to perform this task automatically, thereby helping students to focus more on other non-routine tasks. It can be useful the following guiding question: what skills should they be able to perform automatically, like a routine?

At the time of defining learning strategies the use of scaffolding should be considered. It is recommended to gradually reduce the amount of support as the students approach the final class of tasks. The learning can start with work out examples which fully support the student. Next the student will perform a completion task in which the student is partially supported by the completed information and finally the student is given a conventional problem which the student has to solve, without receiving any support.

It is necessary to provide students with performance support to help them while they are practicing a task. In this sense we have identified three levels of performance support:

a) Didactic level: at this level, the performance support should be structured into the following components: background information, such as facts, definitions, principles and theoretical frameworks; examples, such as worked out examples, demonstrations, and simulations; and, procedures, that is, techniques and tools.

b) Usage level: the learning objects are provided to both learners and instructors enabling them to benefit from the availability of learning objects.

c) Reusability level: consider the elements of background information, examples and procedures, as mentioned at the didactic level as learning objects. These learning objects can be put in a repository and can be reused by different instructors in different combinations when designing their courses.

In order to practice self-directed learning, students can select any class of task to begin with (simple, complex, full support, medium support etc.). However, students should also be informed that a control check is embedded to ensure that the selected task is performed at the required level. Inform students that they can select any time one or more of the performance support components. There is no fixed order for consulting the performance support components.

Lastly, instructors should provide students with formative feedback to inform them on how well they have performed a particular task. Formative feedback does not only tell the students how well the task was performed, but also what students could do to improve their performance. Feedback should be given on the next step to be taken, recommendations based on students' progress and learning preferences. The feedback can either be generated automatically or can be provided by a teacher or coach.

6.4 Summative evaluation

Summative evaluation refers to formal testing of what has been learned in order to formulate a grade or mark. This section describes several aspects of the summative evaluation in order to determine its effectiveness.

First of all, in order to evaluate whether students have developed their competences to a sufficient level that they will act successfully in their later profession, it is recommended to design an authentic assessment. An authentic assessment resembles one or more situations students could encounter in their later profession. The authenticity of the assessment can also be simulated. The authentic assessment should be an accurate copy of the referent situation. The conditions, required performance and success standard should be as close as possible to those in the referent situation.

The assessment will evaluate whether what is taught and trained during the curriculum has been sufficiently developed by the students. Because of this, the assessment should be in line with the learning objectives that have been defined. The assessment should measure whether the learning objectives have been achieved. It is important to make sure that when designing the summative evaluation that the behaviour, conditions and criteria described in the learning objectives are taken into account.

It is recommended to select high fidelity evaluation tools such as constructed responses, hands-on task, observation projects, portfolios and assessment centres, rather than low fidelity evaluation tools (true-false, matching, or different format of multiple-choice) to adequately measure performance achievements of students. Scoring performance assessment formats should be chosen when specifying explicit scoring criteria to define the range of performance level for a task or a sample of work. It is recommended to use verbal descriptors for the performance and a numeric scale (e.g. 0-4) attached to each of them. It is important to

keep in mind that the scoring criteria should be in accordance with the criteria and standards described in the learning objectives.

Finally, instructors should make an informative choice between either holistic or analytical types of scoring methods. In holistic scoring, a global score is given based on the overall impression of the performance. In analytical scoring, separate scores are given on different aspects of the work. In order to define the summative evaluation a number of practical questions have been raised. An example of the guiding questions can be: what kind of tasks should the student be able to perform in order to show me that he has achieved all learning objectives? Or, is it possible to give a holistic score based on an overall impression of the performance?

7. Conclusions

We need that educational institutions improve regularly their curriculum to adapt it to the actual needs of a changing society, from a social, political, educational and labor point of view, what requires creative processes and patterns of action by which to respond to the training tasks. In order to trigger change, innovative models have to be undertaken to improve the quality of education outcomes, making the teaching-learning process more effective and contributing to international quality assurance.

In this sense, two Universities with 4 companies are involved in the PAC project. In the framework of this project, it has been developed complete programs on master degree level responding to the today needs of higher education graduates in Engineering, Information and Communication Technologies (ICT) and Telecom services, since there is a need of new skills requirements of many jobs not only in terms of formal qualifications, but also in terms of detailed skills and competences. Identification of new demands for qualifications and qualifications profile development input the business and employment into curriculum development and course design, to answer to the need of practically oriented/occupationally specific and designed for participants to acquire the practical skills, and know-how needed for employment in a particular occupation programs, which usually provides the participants with a labor-market relevant qualification.

In the view of the above, the benefits both direct and indirect of the PAC project derived from the strategy used to address new learning challenges are listed below:

- ✓ Identifying skills needs and new requirements for competences in Engineering, Information and Communication Technologies (ICT) and Telecom services.
- ✓ Adapting and tailoring science curriculums in Engineering, Information and Communication Technologies (ICT) and Telecom services taking into account the impact of new technologies on scientific work.
- ✓ Development of qualification profiles, including knowledge, skills and competences, focusing on learning outcomes in a curriculum framework.
- ✓ Establishment of virtual research and teaching environments to develop Performance-centered Adaptive Curriculum for analyzed qualification profiles.

- ✓ Evaluation of the skills, knowledge and competences through practical work performance as regards a particular job, trying answering the question: 'Right skills for the right job?'

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