UDC 378

# Tools and Indicators for a Dynamic, Innovative and Optimized Education Program

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**Table and indicators which allow a rapid analysis and comparison of education programs are presented. Among them, the matrix of competences is very useful to check that targeted skills are really fulfilled by the education program. In addition to the analysis of the curriculum, benefits, limits and opportunities provided by innovative learning process like Project Oriented Learning, Reverse Engineering Learning and Online courses are discussed.**

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***Key words:*** *matrix of competences, Reverse engineering, Online courses, Innovative learning process.*

## Introduction

Any Education program has to be designed according to objectives concerning:

- the targeted profile of graduated students, their short term and long term activity and agility
- the requirements and expectations from industry and society
- the strategy of the institute
- the strategy of the state

Society needs, company needs, students' attitude and standpoint are rapidly moving. The technology enables now a very rapid and worldwide access to data, provides new tools for education but also results in a significant change in the time students are able to concentrate hard enough and in the way they are collecting and recording information. Therefore any education program has to be dynamical but also innovative. Considering that any education institute has to respect requirements from accreditation system, considering that its budget is finite and knowing that any academic staff is somehow reluctant to changes or less rapid or motivated to integrate new tools or learning processes, the design of any education program and organization is indeed an optimized process managing many parameters or constraints. In this paper, first the matrix of competences is presented and indicators allowing easy analysis and comparison of education program are proposed. Then Strengths, Weaknesses Opportunities and Threats (SWOT) of learning processes like Project Based Learning (PBL) or Reverse Engineering Learning (REL) are discussed. In a third part, opportunities provided by On Line courses and discussed and fourth part is dedicated to the conclusion.

## I- Matrix of competences and synthetic analysis of education programs

Whatever the level of education, the curriculum has to provide the knowledge and professional/technical competences required for the domain of activity (chemistry, communication, transport, energy, banking ...) and targeted professional tracks (Expert, Manager, Designer, Entrepreneur...) [2 , p5]. The matrix of competences presented in figure 1 allows an easy analysis how competences are provided in each module of the curriculum and is an easy identification process of missing competences. Some clues for changes in the curriculum can thus be provided. This matrix is also a precious tool for external communication from the institute. Furthermore the matrix is useful to graduated students, especially during recruitment interviews : students get aware

of their competences which are listed in the matrix and get also able to name and justify their skills. This competence matrix which is curriculum's content oriented must be completed by other tables mentioning the form or education (classical learning processes, innovative learning processes like Project Based Learning (PBL see II) or Online courses (see III), interships...) related to each skill. Many indicators can also be listed which allow comparison between education programs structure worldwide and exchange of best practices. Indicators like share of Academic staff from industry, share of education in English, share of PBL, share of Online courses, share of humanities, share of interships, number of entrepreneurs among alumni, ... are for example useful indicators.

## II- SWOT analysis of Project Based Learning (PBL) or Reverse Engineering learning (REL)

Project based learning is very fruitful to students for many reasons. They have to take initiatives, use in the most efficient way their knowledge and skills, cooperate and communicate with others. This is an introduction to the 'real world', the professional way of working in companies. Project based learning is relevant for promoting or encouraging acquisition of fundamental or specialized knowkedge and skills but is less suited to acquire them. "Classical" learning processes (Lecture/Exercise/Labwork) are efficient in that case and profitable in terms of time to spend in order to acquire theses fundamental or specialized knowledge and skills.

Reverge Engineering can be organized in a project oriented learning way. In that case, in addition to the usual PBL contribution to education of interpersonal skills, like management and enterprise ecosystem, Reverse Engineering allows a direct connection to education of intellectual property and related strategy, to ethics, and even to state policy regarding protection of national economy.

To sum up, a SWOT analysis of PBL and REL could be the following one (Table 1).

## III- On line courses: opportunities and stakes

Massive Open Online courses (MOOCs) are rapidly growing new opportunities for users (young students or even professionals aiming at updating their knowledge) to learn and even get credits from prestigious Universities. The list of available courses proposed by 'Coursera' [3] is for the moment the largest one thanks to the cooperation of many universities worldwide. Many top universities have also strongly invested in the development of Edx [4] and in many countries digital platform are created to develop MOOCs [5, 6]. For universities proposing MOOCs, one of the payback is the renown, the advertising, the image of a university adapted to the 'Z' generation or 'digital natives' [7]. MOOCs are also the opportunity for a new market related to education and dedicated platforms. MOOCs include an evaluation process and due works that have to be sent by users before deadlines. MOOCs are broadcasted at specific date and time and thus users have to connect to the platform at fixed schedules. A more flexible process also exists and is proposed by some university. In that case, free online courses are available, can be viewed anytime and associated handouts are available [8, 9]. These

**Table 1.**

| Strengths | Weaknesses |
|---|---|
| ■ Motivation of students and emulation<br>■ Providing confidence to students<br>■ Mobilization of knowledge and competences from different modules | ■ Less suited or less efficient to acquire fundamental/spezialized skills than classical highly tutored education process (Lecture/Exercise/Labwork)<br>■ Time consuming due to project management and organization |
| **Opportunities** | **Threats** |
| ■ Can be related to other modules of humanities : Project Management, Communication, Intellectual property, Ethics, Team working...<br>■ Development of industrial partnership: project can be proposed by company | ■ Students may hide behind other<br>■ Scientific and technical Knowledge and skills may not be used or trained because of tasks splitting and sharing between students |

**Fig. 1. Example of competence matrix. Skills are sorted into large domain. If an education module addresses one skill, a value of one is inserted in the corresponding box. For each module, the total of addressed skills is calculated and for each skills the total number of modules addressing this skill is calculated. Skills can easily be adapted to any curriculum. Some skills common to any curriculum can be found in [1] and [2]**

| | Analysis | | | Method | | | Conception / Creation / Innovation | | | | Humanities | | | Special skills of a specific domain For example: nuclear engineering | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Modules | Functional analysis of the problem and segmentation in hardware or software related functions | Critical analysis of the situation a solution, a reasoning | Understanding the physical processes involved in the system | Definition of work planning taking into account avalaible resources (manpower, competences) and technication specifications of a project | Analysis and evaluation of costs and risks | Design or setting method for avoiding or identify possible failure / Design of tests for validation of a solution and validation of specifications | Gathering and development of ressources, knowledge and skills for innovate | Defining of detailed functional and technical specifications | Design of a hardware or software solutions well suited to present or new needs, requirements or standards / Modellisation and Simulation | Stakes, benefits and risks of entrepreneurship / Design of a strategy for concerning intellectual property | Autoevaluation, evaluation of its own role and the role of colleagues | Teamwork and communication | Agility and the ability to self-development and improvement in global environment / Work in a multidisciplinary and multicultural team | Ensuring safety of a nuclear installation | Modeling on of neutronics in a nuclear plant | Operating in a pressurized water reactor | Total |
| Mandatory modules | | | | | | | | | | | | | | | | | |
| Science module 1 | | 1 | | | | | | 1 | | | 1 | | | | | | 3 |
| Science module 2 | | 1 | 1 | | | 1 | | | 1 | 1 | | 1 | | | 1 | | 7 |
| Science module 3 | 1 | | | | | | 1 | | 1 | | | | | | | | 3 |
| Foreign language | | 1 | | | | | | | 1 | | 1 | 1 | 1 | | | | 5 |
| Labor law | | 1 | | | | 1 | | | 1 | 1 | | | | | | | 4 |
| Ethics | | | | | 1 | | | | | 1 | | | | | | | 2 |
| Project | 1 | 1 | | 1 | 1 | | 1 | | 1 | | 1 | 1 | 1 | 1 | 1 | | 11 |
| Internship | 1 | 1 | 1 | | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 15 |
| Elective modules | | | | | | | | | | | | | | | | | |
| Module 1 | 1 | | 1 | | | | | 1 | | | | | | 1 | 1 | 1 | 6 |
| Module 2 | | | 1 | | 1 | 1 | | | 1 | | | | | 1 | 1 | 1 | 7 |
| Total | 4 | 6 | 5 | 1 | 4 | 4 | 3 | 3 | 8 | 4 | 4 | 4 | 3 | 5 | 5 | | |

kind of on line courses are really suited to present and future student attitude and to the technology that allows high rate access to data anywhere anytime. This means that professors can record their lecture, put it on the platform and then decide to replace part of their lectures in lecture halls by sessions of questions/answers, after students listened to the lectures in advance on their tablets when they were the most ready to. Examination can still be organized in the same way as before (which guarantees that students will listen and study the lecture). These lectures will not replace the labworks of the curriculum since many of them (especially ones requiring dedicated equipment or facilities) cannot be provided through MOOCs and online course. Labworks are very efficient time slots for direct communication and tutorials of students and are thus valuable learning processes. Such open on-line lectures, included in the curriculum but free of any embedded evaluation or certification process, are quite easy to implement and can thus be easily designed and shared between partner universities. They will also provide opportunities to students to learn in different languages or to benefit from lectures from experts. These lectures are also suitable to continuing education or distant learning as part of the curriculum.

## Conclusion

Education curriculum and education processes depend on many parameters, culture and tradition, relation with industrial world, needs from the society, technology..... The selection of the content of education modules is determined by the knowledge and targeted competences. The matrix of competences may help to select most suited modules or to adjust modules. Project oriented learning was tested many years ago and is now included in most curriculums. The global and rapid access to data requires adaptation and best use from the academic world (staff and institute) to this technology. The share of education using PBL and online courses has to be fixed according to objectives in terms of specific targeted skills, in terms of improvement of student's self-investment in education and considering that education institutes are in competition not only for research but also for recruiting students. Part of their attractiveness depends of their image and their agility to adapt to innovative learning processes.



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