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Project-based learning framework and engineering competencies in a French Grande Ecole

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Abstract

Our institution, TELECOM Bretagne, is a French graduate engineering school (*Grande Ecole*). In 2003, the programme was changed into a project-oriented framework. This paper describes the recent changes and enhancements that were applied to our engineering education program in order to better develop students competencies; each semester combines pedagogical methods such as project-based learning, active pedagogy and traditional teaching. This evolution brings the students to face the different phases and facets of a real engineering project.

Keywords: curriculum, project based learning, competencies.

Introduction

TELECOM Bretagne is a high graduate engineering school (French *Grande Ecole*) that delivers now several diplomas: engineering degree (master level), engineering degree in partnership with industry, masters of science, specialized masters and PhD. The total number of students is 1100, among them 200 PhD students, 400 engineering degree and 120 engineering degree in partnership with industry.

This paper deals with the new curriculum set for the engineering degree.

Some facts and figures about the engineering degree

The engineering degree is historically the first diploma delivered by our institution; TELECOM Bretagne was created in 1977 in order to train high level training in telecommunication engineering with a focus on international; TELECOM Bretagne engineers are employed in all economical sectors. As in other French *Grandes Ecoles*, the link with industry is tight and the education spectrum is wide: it includes electronics, computer science, networking, data processing, projects as well as economical and social sciences and two foreign languages.

Concerning the recruitment, most students (75%) are admitted in the first year of studies through a highly selective examination after two years in undergraduate preparatory schools. In this case, the cursus duration is 3 years. Other students, especially international students, are recruited in the first and second years after graduation from universities. In 2007-2008, the ratio of foreign

students is 44% (among them 42% are not native from French speaking countries) and 45 nationalities are represented on the campus.

Aims of the new curriculum and description

The cursus shall provide a general training in the field of information and communication technologies and their applications: telecommunications, automobile, bank, finance, health, teledetection, ... It shall include general education for engineers like economy, management and a system approach.

More over, the new curriculum has been built by taking into account the following issues:

- The new curriculum shall help the student in building his own life project; the recruitment based on a high selective examination doesn't put the professional project in the center of the student's training. Hence, the curriculum has to be flexible in order to make possible the emergence of the student's own professional project.
- The increase of recruitment sources and the changes in the student expectation: the same programme can no more be applied to all the students; as the total number of students increases, it is more difficult to manage large number of students.
- The internationalization of the curriculum: the international orientation has to be reinforced not only by learning two foreign languages but also by making possible internships or stays abroad. In order to do that, the curriculum has to be built in semesters, and to take into account European Credit Transfer System (ECTS).
- In addition to expectation of industry and Europe, competencies, are necessary to practice engineers jobs [1]; the description of the training by competencies shall allow a better comparison of education and diploma.
- The students demand for more practical works and projects and less lectures. Using intensively internships may develop skills but without giving the requisite pedagogical control to the teaching institution. On the other hand, it is also necessary to train them to work in groups about engineering problems requiring compromises.

Consequently our institution implemented few years ago a project-oriented framework combining pedagogical methods such as project-based learning, active pedagogy and traditional teaching paradigms. A competency-driven approach was set together with the specific pedagogical methods required for the skills and attitudes that are difficult to develop through traditional teaching.

Finally, the curriculum was set as follows:

- the first semester (S1) is common for all students; it provides some theoretical bases (taught by classical methods) as well as the first work in group (project "introduction to complex systems").
- semesters 2, 3 and 4 allows the student to customize his programme; each semester, he has to choose one minor (84h) and one major (168h) among the five following matters: mathematics and signal processing, electronics and physics, computer sciences, network,

economy and human sciences. A specific minor aimed to “practical work and measurement” (84h) is compulsory. Each semester has a specific project (described in the next paragraph).

- Semester 5 is an options semester; students put together their options by choosing courses from one or more of the following options: Engineering and system integration, Software systems and networks, Services and business engineering, Information processing systems.
- Semester 6 is devoted to the final internship (6 to 8 months long).

Internships can be inserted between every semester: for instance, a student could have an academic semester each autumn and make an internship each spring. A break in the studies by making “a year in industry” between semester 4 and 5 is encouraged, and elected by most students.

For French students, at least 3 months stay abroad are compulsory; this requirement can be achieved by making an academic semester abroad or by making an internship abroad, or just by working abroad.

Moreover, additional courses can be followed by the student in French universities (for instance, Bachelor in mathematics during the first year).

Finally, flexibility is given in terms of:

- time (semesters 2 to 4 offer the same choices; internships are possible between two semesters)
- level of competency in each domain (minor/major)
- location and kind of stay abroad (internship/academic semester)

Hence, the student builds step by step his own professional by making choices each semester.

To train students for projects, via projects

The main thread of the change of curriculum is to train students for projects, via projects.

Transverse competencies (communication, working in group, learning to learn, project management,...) and technical competencies (specification, design, system development, interdisciplinarity) [2] respect a progression all along the projects, as shown in table 1.

Table 1. : competencies developed in the projects

	Semester 1	Semester 2	Semester 3	Semester 4
Transverse competencies	Analyzing and specifying in groups	Technical design and development, in relation with research labs	Creating a new product or service	Answer to a need of an external partner
Technical competencies	<i>Utilize</i>	<i>Utilize</i>	<i>Utilize</i>	<i>Utilize</i>
Working in a team	<i>Teach</i>	<i>Utilize</i>	<i>Utilize</i>	<i>Utilize</i>
Communicating	<i>Teach (Oral)</i> <i>Introduce (Written)</i>	<i>Teach (Written)</i>	<i>Utilize</i>	<i>Utilize</i>
Creating, innovating	<i>Introduce</i>	<i>Introduce</i>	<i>Teach</i>	<i>Utilize</i>
Managing projects	<i>Introduce</i>	<i>Introduce</i>	<i>Introduce</i>	<i>Teach</i>
Name of the project	“Introduction to complex systems”	“Development”	“Entreprising”	“Engineer”

The pedagogy used depends on the pedagogical objectives of the projects. Active pedagogy is favourable for projects in which focus is given on working in group and self learning (semester 1 and 3, in which new students enter the school). In the project more focused on technical development (semester 2), classical supervisory is made by the teacher who proposes the subject; he advises the students for technical know-how and choices. In semester 4, the subject is proposed by an industrialist (the client), two supervisors from different domains (to guarantee the pluridisciplinarity of the project) and a supervisor specialized in project management (this project focuses on project management).

Brief description of the projects

In practice, students work each semester in groups on a project lasting over 100 hours per student. Those projects have been chosen to browse different aspects related to the engineer’s activities and gradually lead the students from a classical disciplinary approach to a transversal and system-level point of view. The projects are attached to identified competencies, both technical and transversal [2].

1. The first project (Semester 1), “Introduction to Complex Systems”, is dedicated to the browsing of disciplines, problems and strategic dimensions of the telecommunications field. It occurs at the very beginning of the students training and also aims at take them out of their strong disciplinary specialization (mathematics / physics). It is based on active pedagogy and focuses on working in groups (groups of 8-9 students are constituted not on the basis of volunteers, but by the teaching staff with criteria like the former studies, the participation of several nationalities,...). Hence, it is a first transition between the transmissive approach of

their former studies and their future professional work. As an example, more details about the pedagogical objectives of this project are given in table 2.

2. The second project (Semester 2) aims at designing a technical device/object in a discipline of one our research laboratories, in group of 3-4 students. In addition to technical competencies (designing and developping a technical solution, testing, assessing and validating solution elements, applying an appropriate methodology), a focus is put on written technical documents.
3. The third project (Semester 3), with groups of 8-9 students, is devoted to creativity and to the technical and economical feasibility of an innovative project, on a wide societal topic (ICT and health, ICT and transportation,...). The purpose of the project is to make a technical and business plan on the new service/product, in order to convince decision makers to finance the idea. Creativity and innovation methods are taught as well as argumentation techniques.
4. The fourth project (Semester 4), made in groups of 6 students, targets a system / project level, while students must care about a complete project life cycle, from customers requirements (projects are proposed and defined by external industrial partners) to the final product and its acceptance. Those system-level projects may of course integrate some technical (or economical) elements that have been designed during previous S2 projects or imagined in S3 projects, thus setting a possible continuity between the whole projects-line. In addition to project management, conducting meetings and trading with a customer are key competencies addressed by this project.

Table 2. Pedagogical objectives of the project « introduction to complex systems » (semester 1)

Methodology; organising the work in a group	O11: ability to know his own role, to recognize and accept the role of everyone, in a group of 7 to 8 students
	O12: ability to share a set of tasks equitably
	O13: ability to estimate the time required for a task (introduction level)
	O14: ability to listen to the others during a meeting
	O15: ability to lead a group during a working session
	O16: ability to take notes during a meeting, to make a report and to use them.(introduction level)
Organising the production within a group	O21: ability to build a common base of knowledge, useful and judicious for the group and the project
	O22: ability to explain the results of his own work to the other members of the group
Communication	O31: ability to describe the solution while mastering the vocabulary used
	O32: ability and be used to cite bibliographical references and sources
	O33: ability to criticize the information and sources used in the project (introduction level)
	O34: ability to present orally the work of the group to engineers
	O35: ability to write technical documents in French while respecting given rules
Analysis of a global technico-economical problem	O41: ability to split up a complex system into subsystems and to identify the main functions
	O42: ability to discern the economical constraints linked to the design and development of a complex system in a given environment
	O43: ability to split up a particular subsystem into elementary functions
	O44: ability to make links between the project and the domains taught under classical forms

Technical synthesis	O51: ability to design various solutions by using the knowledge acquired by the group members
	O52: ability to compare various solutions and to select a suitable solution
	O53: ability to build a judicious set of criteria for comparing the solutions

Accompanying the changes

In order to make these changes possible, the teaching staff and the students have been accompanied by specific processes. Procedures have been set in order to improve the projects step by step.

Education of the teaching staff

Active pedagogy and the use of competencies in education were quite new for us, when we first visited the Catholic University of Louvain (UCL) in 2002. Since that time, one third of the teaching staff has been trained to active pedagogy by UCL staff [3].

Moreover, specific education units are also taught in order to accompany the projects: the concept of functional specifications, for the “introduction to complex systems” project, creativity methods for the “enterprising” project, project management for the “engineer” project.

It is to be noticed that all these projects are multidisciplinary and that the supervisors are lecturers in as various domains as electronics, computer sciences, economy and languages. These training sessions give then a common knowledge core to the teaching staff.

In addition to this, briefings and debriefings are set all along the projects in order to maintain the motivation of the supervisors and the coherence of the training. This is important since the other scientific domains are mainly taught by classical methods; such discussions are also a way of enhancing the projects.

Understanding the objectives

The 5 year experience of this project-based framework has shown that it is absolutely necessary to explain very clearly the objectives of the projects – otherwise, the students are destabilised by teaching methods which are so far from the traditional teaching they experimented till now. This is why each project now starts with a “kick-off” session (3h). This session made in active pedagogy addresses the various phases, constraints and risks of the project.

Enhancing the projects

Each project is evaluated by the students and also by the teaching staff. Constructive discussions are made first within the project committee (9 to 10 teachers from different departments) which proposes changes to the project centralizing committee. This committee is constituted by the project coordinators, the dean of academic affairs and a communication teacher. The aim of the project centralizing committee is to coordinate the set of projects, to discuss and validate the modification for each project.

Conclusion

Since the change of curriculum, the student is prepared, at the end of the second year in our institution, to transverse competencies and to the interdisciplinarity of the engineer job.

Concerning the teaching staff, the number of lecturers educated to active pedagogy continues to increase; the interdisciplinarity vision is strengthening and reaches now traditional courses. Competencies were introduced through this project based framework; they now reach the other domains and traditional courses; a competency referential is under development. This evolution aims to train the students to work in the context of innovating and complex technological projects.

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Biographical Information

Jean-Marie Gilliot obtained his Ph.D. in computer science in 1990. From 1991 he was a Lecturer at ESIEE engineering school, and in 2002 he joined the Department of Computer Science at TELECOM Bretagne. Involved in Project-Based Learning for 15 years, he is a co-designer of the S1 and S2 projects. He's now the manager of the project-framework centralizing committee. His research interests in robotics and embedded systems convinced him of the importance of an interdisciplinary curriculum in engineering.

Gabrielle Landrac is dean of academic affairs in TELECOM Bretagne since 2007. She did her engineering degree at TELECOM Bretagne in 1986 and obtained her Ph.D. in Electronics there in 1989. She is a professor in Electronics and Telecommunication Systems Department at TELECOM Bretagne since 1989. She was the coordinator of the S1 project design group and the manager of the project-framework centralizing committee from 2003 to 2007.

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