RENOVATION OF AN ELECTRONIC ENGINEERING CURRICULUM

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INTRODUCTION

Nowadays, electronic engineering is often one of the less attractive subjects of engineering studies for young students; many factors can be quoted to explain this fact such as for example stereotyped ideas on the discipline.
However enterprises still need competences in the field and master's graduates in such matters, this need is nowadays increased because of the importance of electronic devices in the management of energy. This lack of graduates leads the responsible of curricula in these domains to have a deep reflexion, both from the pedagogic point of view and from the marketing point of view to imagine new ways of teaching and presenting electronics.
In Polytech Orléans we began such a renovation of the curriculum in 2008, and now things have been improved: the number of students interested in those studies increases continuously.
Several approaches have been combined:

- a change in the communication about the curriculum that is no more presented in disciplinary fields but in profiles corresponding to the jobs

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- an introduction of active pedagogies and more specifically project based pedagogies
- an organization of the course which reinforces the coherence of the subject: the theoretical and practical subjects concerning the same domain are taught in the same module.

After a recall of the global and local contexts, we present the method we used to reform the Electronics Department, involving internal and external stakeholders, and the new study profiles which are: Smart building, Nomadic systems, Energy valorization

1 CONTEXT OF THE REFORM

1.1 Global context

In France, since the nineties, difficulties to attract students towards electronic engineering exist, they occurred first in classical universities and then in technical universities. The professional syndicates of the field helped academy to realise communication operation so as to indicate that enterprises of the domain needed graduates but they had few effects!

Disaffection of students regarding scientific studies and especially electronic ones has been often studied [1] [2] [3] and several European projects realised [4]. It is useful to be informed about those studies and their results. However, as change of a curriculum is part of a global process of evolution, adopting an existing solution fitted to one particular situation is not possible, since the dynamic of change of an institution should include persons at all level of this institution and because these people are specific for each institution. Nevertheless, a combination of solutions proposed by studies and papers on the theme can lead to great improvements.

The choice of a Master degree is complex for students; it depends of the perceptions of the studies by themselves but also of the interest of job that will be offered when they graduate and also now, very often, of the social representation of these jobs. The weight of stereotypes is heavy, these stereotypes being transported by media, by families. At this moment in France, studies in Civil Engineering are the most attractive amongst the studies in engineering. This lasts since the Viaduc of Millau building, as this bridge was the triumph of technology and design and was very often described by media. Furthermore, during the same period, studies in civil engineering were very often linked to those of ecology because of the necessity to understand geology and things related to soils and water systems for civil engineering activities; this fact increased their societal value.

The specific context of electronics in mind of people is complicated because, some years ago, delocalisation of electronic production in Asia drove to unemployment in Europe in this field, but what is not very often said is that the jobs suppressed were at low level of qualification. Employment of engineers in electronics resists to crisis, it is even the only domain where, thanks to the great number of positions that need to be occupied, salary for beginners is the same for male and female graduates.

The role of parents must not be neglected even concerning Master's level studies: during the eighties, many teachers in the field of electronics wanted to attract only the best students which were still numerous in science and technology. It was often said "only best students can succeed", "it is a curriculum made for elite with a very good level in mathematics"; even if things have been changing in the universities, those ideas continue to go their way in the minds of the previous generation.

So, electronics subjects bear the paradox to appear as well as very high level theoretical ones and as subjects with practice of low level, refraining as well students that need to understand the usefulness of what they are learning or those not having enough self-confidence as those not willing to put their hands in the dust!

Moreover, when bachelor and master degree take place in the same university, informal dialog exists between students of both levels and influences also their choices whatever the institutional communication is!

In Polytech Orleans, all these factors coexisted and we will now see more in details these problems and how we tried to solve them.

1.2 Local context

Polytech Orléans graduates since 1992 engineers in the field of electronics; this curriculum has duration of 3 years and provides the graduate with a Master degree. Students that we recruit at the entrance of this curriculum come from a preparatory course which is common to 13 engineering universities of the same brand. The arrival of students in the 3 year final course depends on their wishes and academic results during the two years of the preparatory course and not of an examination. Furthermore, we can say that from several years, because Civil Engineering curricula attract students very much, it is only the wishes of students that determine their admission in the electronics courses. Between 2005 and 2008, the number of students in our course has been divided by 2, as shown on *Figure* 3.

The effect of the circulation of information is also very important in the wishes of students: some students do their preparatory course in the same school as our electronic engineering Master; all the students have common associative activities where they speak together: if something goes wrong students immediately know it!

However all of them knew that it was very easy to find jobs in Electronics; in 2008, when the recruitment in the course was the more difficult, 80% of the graduates were finding a job before 2 months after the end of studies and each year the average salary for beginners increased of 10%.

We will now explain some of the facts surrounding the problem of our curriculum and explaining the necessity of a change.

Since several years, France is undergoing a demarche to merge higher education institutions together so as to create institutions of the same size as those of other continents. In Orleans, in 2002, three curricula were put together, these three courses did not have the same pedagogic approach at this moment but they had to standardize it; we can say that the electronic curriculum had already innovative pedagogic approaches such as a rather developed pedagogy by projects, and that it had to stop them. After 2005, when the curriculum was no more attracting students, it was quite difficult to ask and obtain that the teachers change again the curriculum: they were tired of these changes, but at the same time convinced that the pedagogic approach used before merging was not so bad.

Very often it is easier to do reforms when things are at their worse; it is certainly what happened concerning Polytech in 2008! Furthermore, the decrease of the number of students has a threshold effect: less students gives less work to the teachers and let them more time to make research but too few students lead to the closure of the curriculum and to the necessity for teachers to teach completely different subjects that sometimes are not in their initial skills.

2 METHODOLOGY OF THE REFORM

The direction of the school and the staff responsible for the management of the course came to an agreement that the reflexion on attractivity of the curriculum could not be separated from a deep pedagogic reform fitted with the fact that our students had changed. This demarche should include team of direction, teachers, students, external stakeholders; this was coherent to the studies concerning the dynamic of change that must be shared by all [5].

To obtain success in a reform with the same pedagogic team as before the reform is not obvious and sometimes people [6] think that is better to build from zero!

However we had not the opportunity to do so, and it appeared that active pedagogy at a high intensity is not so evident because the role of teachers changes a lot, generating a kind of fear amongst them. Moreover, the benefit of a deep reform cannot be proved immediately: the demonstration requires several years of practice and this can let opportunities for discouragements and revolts against management. So the fitting of speed of the reform was an important parameter and the accompanying system that should be put in place too.

In November 2008, the specifications given by the direction of Polytech to the Electronics department included three directions:

- increase the attractiveness of the curriculum
- draw the inventory of the learning outcomes of graduates
- imagine and put in place a pedagogic evolution including as well evolutions of contents and of organization

The real challenge was to make teachers agree and cooperate to the renovation work, through a renewal of the enthusiasm of pedagogic teams. Studies realised by researchers on engineering education showed that it is one essential part of apprenticeship!

A working group (WG) has been constituted. It included the responsible of the course and of the options of the course but also a teacher of the school specialised in the domain of management and human resources, a teacher of electronics working also half time in an industrial resource centre of the domain and the responsible of the relations with enterprises of the school.

It had been previously decided not to include immediately people representing enterprises in the team not to generate susceptibility of the teachers. Moreover, in 2008, the easy insertion of the graduates showed that the course was fitted to the needs of recruiters. It was less necessary to deeply modify the content of the course than to make it evolve so as to anticipate new jobs of the domain.

This working group met at 9 occasions to prepare the first year of the new program (2009), then at 6 occasions to prepare the second year and to adjust the reform taking into account the problems that arose during the first year; only one meeting of the group was necessary to prepare the arrival of students in last year in September 2011.

Concerning the aspects linked to the marketing of the course, the WG tested its hypothesis thanks to two enquiries realised amongst the students of the first and second year of the preparatory cycle and also on the external students that visited us during the open days of February 2009; in France, open days allow people from outside the university to visit the laboratories and classes and to discuss with the teachers and students of the school.

3 POINTS ON WHICH WE HAD TO CHANGE

3.1 Name of the curriculum

Name of engineering curricula is something that can seem without importance. However for young people, it is one element which can refrain, either if the name is only the name of an academic subject, or even sometimes if this subject is not one of the subjects previously taught to the student.
In 2008, the communication about the course was based on an academic representation of subjects. It was necessary to go towards a communication on professional domains and so let student dream of one's future.
From the accreditation point of view, it is impossible in France to give to a course name outside of the list of the accreditations given by ABET; those names are more or less name of domains of activity; we decided to use two different names for the curriculum: the legal one and the one used for communication. Most of the technologies taught in the curricula have something to do either with energy or with sustainable development in the broader sense, so the communication name chosen is "Ecotechnologies". Young people are very concerned by future of the planet; some of them did not imagine previously that electronics can be a contributor to sustainable development but now they are aware of that.
After having analysed the competences of the graduates, it was clear that the domains of activities concerned by the course could be synthesised in 3 profiles:

- valorisation of energy
- smart building
- nomadic systems

The profile of each student is partly determined through the subjects he learns during the last year of the curriculum, but also in a great part by the projects realised during the teachings of the whole 3 years and by the internship realised.

3.2 Development of the pedagogy by projects

Limiting the evolution of the course to marketing or communication would have had no sense and no effect. It was necessary to increase the implication of the students in their apprenticeship; active pedagogies are a good way to do so.
Engineering education has been concerning the presence of projects in the curriculum very early with respect to other domains. Traditionally, these projects concerned mostly the last year of studies.
What is new in our course is that these projects take place from the beginning to the end of the curriculum and that their leaning outcomes are carefully described and assessed; the realisation of a project gives sense to the teaching from the point of view of the students. These projects are issued from a problem issued from enterprise or laboratory, scientific knowledge needed for the solving of the problem is acquired by students.
During the first two years, each of the projects lasts 50 hours and takes place in the presence of the teachers, it can be realised by 1, 2 or 3 students; knowledge about project management is acquired too in addition to scientific knowledge.
Each project corresponds to one of the three profiles of the course and a learning outcome portfolio is the pedagogic assessment document. The teachers concerned complete the document to follow the evolution of skills acquired in each domain: realise a pro forma, realise a planning, manage a project, animate, conduct a team, communicate, live together.

Global assessment of projects is based on the work realised, on written report and oral presentation.

3.3 Organisation of the curriculum

In 2008 the organisation of the course was dichotomist as shown on *Figure* 1, with a quick separation according to disciplinary fields between optics and electronics. This organisation is very comfortable for teachers; it does not any more fit with minds of young people

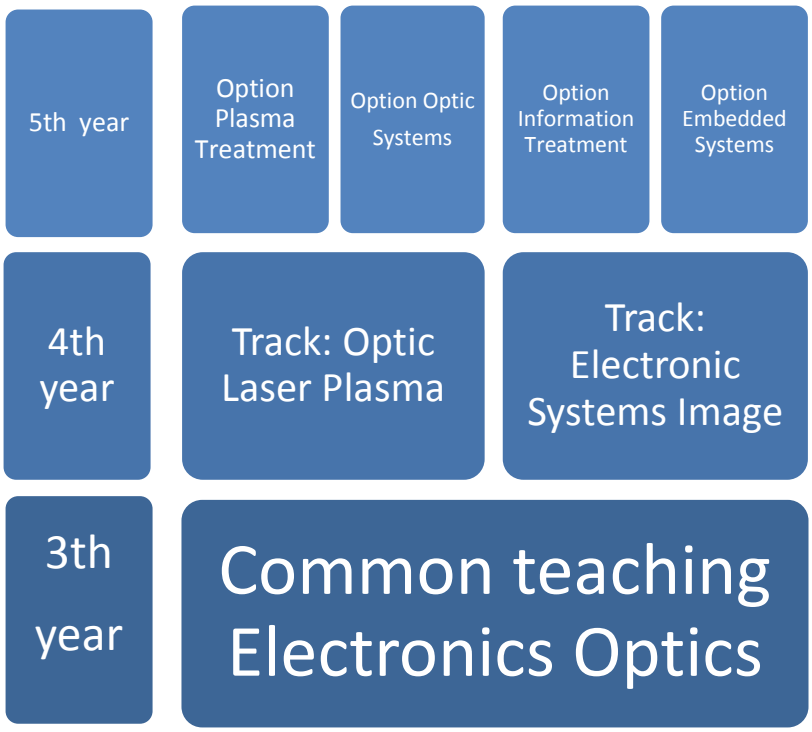

Figure 1: Structure of the course in 2008

Traditionally theoretic subjects were massively placed at the beginning of the curriculum, while their interest appeared to students only during the last year; an organisation which is conforming to a professional logic gives more sense to apprenticeship. The first year of the course very theoretical was hard for the students they very often had forgotten what they had learnt at the moment to use it during the 2nd or the 3rd year!

The course was organised in separated modules of 56 hours and students had difficulties to make a link between these scattered subjects and their application.

In the new organisation showed in *Figure* 2, all students follow the same teaching during 2 years. The modules have been concentrated in Teaching Units (TU) concentrated along time: 2 TU lasting 7 weeks take place each semester. We must say that the administrative task to organise planning is more difficult than before, but coherence of teachings is increased. Moreover, it becomes possible to apply immediately the skills learned in an internship and to open the course to older people having continuing education while working.

The teachings of the first year correspond to a system approach: for example at the end of the TU “Lighting” students can realize a smart management of a system of lighting.

Track job		Photonics	Embedded vision	Plasma engineering	Autonomous architectures
5th year	S10b	Internship ≥ 17 weeks mini	Internship ≥ 17 weeks mini	Internship ≥ 17 weeks mini	Internship ≥ 17 weeks mini
	S10a	Project 8 weeks	Project 8 weeks	Project 8 weeks	Project 8 weeks
	S9b	TU laser process	TU operational imagery	TU plasma process	TU hardware design
	S9a	TU optical systems	TU ambient informatics	TU plasma sources	TU numeric treatments
4th year	S8b	TU lasers			
	S8a	TU industrial imagery			
	S7b	TU micro et nano technologies			
	S7a	TU informatics			
3th year	S6b	TU domotics			
	S6a	TU lighting			
	S5b	TU multimedia			
	S5a	TU tools of the engineer			

Figure 2: The new course

In each of the TU, the pedagogy by projects is systematic, between 4 and 6 learning outcomes can be assessed in each of the TU with 3 possible levels: methodological ability, ability to use tools, information and communication.
Each of the TU lasts 200 hours during 1st and 2nd year: amongst them, 150 hours in presence of a teacher include a project (50 hours in groups of 16 students), distance learning sequence, self learning and theoretical learning. The 50 remaining hours are Periods to Learn in Autonomy (PLA). These PLA are intended to develop the autonomy of students and prepare them to their work in enterprise. They are scheduled and appear in the planning, and take place inside rooms in the school. The work to be done is identified before each PLA. It is assessed at the end of the PLA. During PLA, students use the software pedagogic platform of the school.
During the 5st year, each TU lasts 175 hours (50 hours of PLA included), and the final projects have duration of 200 hours and take place after the TUs.

4 RESULTS AND CONCLUSIONS

We can see on *Figure* 3 that the reform has been fruitful concerning the attractivity towards students.
The year 2009-2010 has been the more difficult because at this moment at the same time, enterprises that were recruiting our graduates feared a decrease of their level due to the reform of the studies while the teachers had a lot of job to do to modify their ways of teaching; at this moment it was still impossible to know if the reform would succeed!

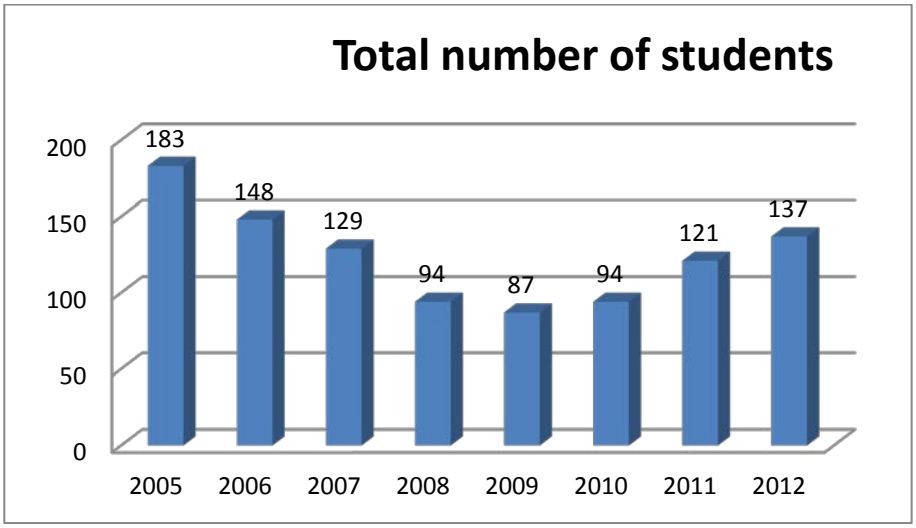

Figure 3: Evolution of the number of students

We can say that our graduates are more and more appreciated by companies, and that the reform has been a success, you can consult the detailed program on the web site of Polytech [7].Things would have been easier if a methodological teaching on the pedagogy by projects could have been given to our teachers, but this was not possible to organize it due to lack of money.
Things can still be improved but in a continuous way. For example a greater choice of projects especially those related to societal utility could concern new psychological profiles of students as can be seen in the demarche of “learning by services”.

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