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Design of new engineering curricula: combining enterprises needs and interest of student, the case of smart buildings

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ABSTRACT

Facing the disaffection of students for electronic engineering studies, we decided to have global brainstorming with students and then with teachers and enterprises to define new engineering courses that could be attractive and useful. The paper describes the problematic addressed, the way we used to build this curriculum and the new course as proposed to the students. We also emphasize all along the text on the problems we had to solve till the attribution of the accreditation.

Keywords

Smart building, sensors, networks, energetic efficiency.

1. INTRODUCTION

Since 10 years, electronic engineering, that was in the years 1980 the area attracting the best students, is no more attractive for young people. However the need for such competences [1] is still very important and engineering universities and enterprise spend together a great energy to find remedies to this crisis of vocation for electronic matters [2].

The development of a new curriculum concerning smart building is a part of this work. It cannot be the only manner to solve the problem, the evolution of secondary schools to prepare the minds of pupils and show the interest of technologic fields (as a fundamental element of the multidisciplinary scope of sustainable development) is another one, and the two approaches are linked.

2. CREATING AN INTEREST FOR POTENTIAL STUDENTS

In 2008, in our school of engineers, the electronic department was at its lower level concerning the number of students.

The board asked to the head of department to find a solution to this problem, this solution had to be at the same time linked to the learning outcomes of the curriculum and to the communication towards the potential students. The project quickly turned to a

curriculum linked both to energy engineering and to building engineering because the teachers were conscious of the strong interest of students concerning both sustainable development and civil engineering

2.1 Interest for ecology

From some years, in France there is a very strong interest of students about the environmental part of sustainable development; as an example, our department of civil engineering which is at the same time a department of environment saw the number of students increase in a very important way; in the same time, engineering curricula linked to energetic, as power electronics engineering for instance, become attractive to student if their name becomes energetic engineering. So we first decided that engineering electronic department should be called eco-technologies engineering department because the techniques taught are applied to problems of energetic efficiency, energy valorization or improvement of everyday life.

Even if some older teachers did not agree, marketing cannot be considered nowadays as a foreign consideration in education; giving two different names to the same course can be a good thing too: the “commercial name” being used for the communication towards students and the more classic one towards enterprise.

Then, during a day where university is open to potential students, we made tombola where it was possible to earn games console. To be a participant to that tombola, it was necessary for the pupil, to order according to its own interest some potential application of electronics. At the end of the tombola, the idea of smart building definitely emerged.

2.2 Multidisciplinary and attractive course

In Polytech Orleans, in 2008, there were at the same time an electronic department, a civil engineering department, an energetic department and a material department; this means that the teachers already recruited in Polytech Orléans could possibly teach in all these fields, but the reality was quite different because once arrived they were “enrolled” in only one of these departments. To build a cross-curricular course is not easy because the teachers are not used to work together through departments; but things that could not exist in normal circumstances can be realized when there is a real problem of recruitment and a strong encouragement of stakeholders!

Moreover the problem of innovation in Europe is questioned and the responsibility of engineering universities in the lack of technical innovation is criticized in many reports. Innovation supposes the interference of different disciplinary fields to create new ideas. Schools of engineers that integrate those different fields but also management, economy law and marketing should be the “top models” of innovation.

The last strong incitation is the fact that the board, very concerned by the lack of female students, also encouraged this initiative because project like Helena [3] show that girls are more attracted towards multidisciplinary curricula.

3. NEEDS OF ENTERPRISES

3.1 The problem of energetic efficiency

According to the action plan of European Community concerning energetic efficiency, in 2020, European Union must have reduced of 20% (with respect to the level of 1990) the emissions of greenhouse gas, reduce of 20% the electric consumption, increase of 20% the part of renewable energies in the total consumption of energy.

In France buildings use 43% of the total energy and transports use 31% of it.

The buildings constructed before 1975 use more than 450kW/m², buildings constructed since that date without particular application of norms between 150 and 250 KWh/m² and buildings constructed in respect of norm RT 2005 between 50 and 100kWh/m².

We see on these figures that it is still too much, so the next steps necessary to satisfy requirement of EU are: Low Consumption Building (50kWh/m²) but even more passive building (<15 kWh/m²) and especially Positive Energy Buildings.

In the house 33% of the energetic use of families is done by the electric devices: for these devices, it is necessary not only to consume less energy when they are used, but also when they are in vigil, 14% of electric use inside the house is the fact of lighting; if there is a good automated management of all these devices, a strong reduction of the consumption can be expected. Concerning electric heating, decrease of the temperature of 1 degree during 24 hours reduces the electricity use of 7%.

A better isolation and a better design of design is not enough to fulfill requirements of EU, it is necessary to make building become "intelligent" thank to electronic devices.

3.2 The lack of engineers acting as integrators

The analysis of the needs of enterprises concerning recruitment of engineers in the sector of the technical building management showed that electrical engineers and computer-science or automation engineers only partially meet the needs of professionals. Engineers at consulting firms are able to design an acquisition chain (sensor and conditioner) and the processing (scanning and signal processing) of a quantity related to this technical building management (temperature, degree of humidity, light level...); moreover, they are able to develop multi-sensor architectures that can exchange information using various existing communication media (wired, optical, wireless...). But, their lack of knowledge of the standards relating to building, of the main features of the different materials used in building, and of the

thermal aspect of the building does not allow them to offer optimal solutions. At the extreme, the system designed can be totally ineffective when installed in a building, because this ignorance of thermal-energy aspects of the building does not allow them to take into account all the constraints in designing such a system.

Our smart building course aims to train R & D engineers with strong skills in electronics and computer-automation science, able to understand, analyze and take into account all constraints related to building and the environment in which it is located. These field engineers, with a dual skill electronic-automation and computer from one side and energy and thermal of the building on the other part, will be powerful actors in establishing relevant specifications relating to the introduction of intelligent systems in and around the building (e.g.: fire protection, thermal regulation, management of openings, lighting, taking into account different energies, application of labels). Smart building engineers will be able to analyze the problem and find innovative solutions in comfort (technical management of buildings, multimedia...), home support (disabled, elderly), both in new buildings and renovation after an audit of existing buildings, for individual or collective, in manufacturing and services.

The multidisciplinary aspect of their field of expertise will enable these engineers to be more effective in innovation, in fact, this will be quite necessary because these engineers will be the pioneers in their field. To ensure the continuity of this double competence at all levels of the building industry, these engineers will have to train both integrators and installers but also their own employees.

Moreover these new engineers must be able to act on integrators to find global solution for energy management, air management and water management in the buildings. The concept of smart grids leads us to consider not only solution for intelligent building but also to the problem of the new cities because for example the problem of soft travelling impacts with solutions linked to the building itself.

4. BRAINSTORMING OF TEACHERS FOR INTERDISCIPLINARITY

The first step was to mix teachers and researchers in electronics, renewable energy, materials and mechanics, heat energy, networks, automation, and more generally all those who feel concerned by the concept of smart building.

It is not a trivial demarche because in France teachers are also researchers and choices in superior education impact on both fields.

We decided, after a global explanation of the “building of the future” made by people from enterprise and people already conducting researches in a part of this field, to list, in the first time, the skills necessary for job linked to smart building; we wanted to be able to work from learning outcome to define the content of the course, as our accreditation organism CTI asks us for some years. The teachings necessary should be defined afterwards only. The discussions were conducted in a rather pleasant atmosphere because only people really interested came in the design team.

4.1 Discussions to reach an agreement concerning the curriculum:

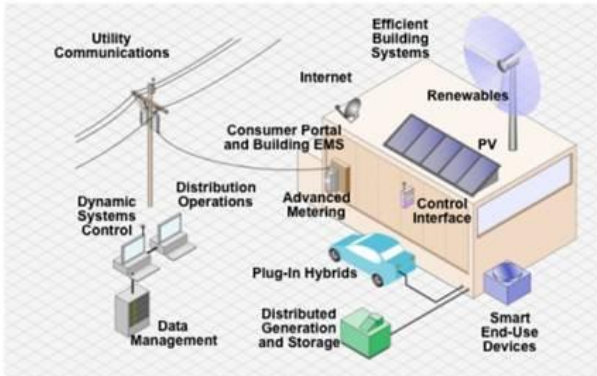


Figure 1. Smart Building according to Electric Power Research Institute

The debate between teachers was about the fields really concerned by Smart Building and in which percentage they should be taught.

The concepts cover large fields (see Figure1) because tomorrow house will be seen as a global entity, moreover the problems attached aren't limited to those of energetic efficiency but they enlarge to care or safety [4], [5].

The team of teachers came to an agreement to define the fields concerned by the course:

- management of the building so as to make it more efficient: new sources of energy, stocking of energy, thermal comfort integrating all the sources of energy, water, quality of air
- management of all the channels of information inside the building (voice, data, images)
- caring of people at home
- security of buildings and persons at home
- link with smart grids

It is important to consider all these points as a part of a more global solution, because the engineer has to propose solutions that can evolve.

Moreover the choice of pedagogy used can be decided for each of the items: apprenticeship based on problem or projects is possible in many courses; at this moment teachers are not in the same degree of knowledge concerning these new way of teaching so, even if these new methods are strongly recommended by CTI for apprenticeship, in a first time, only the presence of projects was considered as mandatory.

4.2 The result

The teachers defined first the great disciplinary fields concerned and then in each of them what was the learning outcome expected

The classification of skills leads us to the following items

- Technical management of buildings
- Design of electric or electronic devices for building
- Management of energy inside buildings

-Eco-design of buildings

But they discussed also about the pedagogy: the necessity of keeping the interest of student, showed us that it was no more possible to teach mathematics for the treatment of signal during the first year of the school and then image processing two years after. The organization of the teaching must be made in units where the full process must be present from the basis of mathematics or physics to the final use of them, each of these units closing by a small application project.

These meetings and discussions were a quite innovative approach for the teachers, they revealed to be completely successful because they listened to each other, many of them feel concerned by environment, and some of them have at the same time a position in the school and in an enterprise.

When the strong points of the course were decided, the group of teachers had to work in two groups to be more effective in the content of the courses: one group was composed with teachers in electronics, computer science, and the other group was composed with teachers in materials, mechanics, sustainable buildings, thermal science.

5. THE INOVATIVE CURRICULUM

The definition of the name and contents of the units results from the work of the two group that at the end of the process work again together to be sure of the coherence of the curriculum

It results in the final course that about 2/3 of the teachings concern the points of view of the IEEE engineer and 1/3 the point of view of the building engineer.

5.1 Content

All French engineers have basic knowledge in mathematics, computer science and management of project, but in this particular course, 3 great areas have been considered as the heart of the teaching:

- Management of energetic needs
- Management of people and assets
- Habitat and environment

The first item includes energetic optimization, ecodesign, renewable energy, management and optimization of energetic needs, home automation and electric devices for home comfort.

The second one is related to sensors, communication networks, interoperability, multimedia, video surveillance, safety, caring people at home

The third one concerns waste and water treatment, environmental norms about buildings, Electromagnetic compatibility.

Those points are then declined according basic teaching areas: electronics, automation, computer science, mechanics and materials, energetic, heat energy.

As the university is situated close to a school of art and design, common projects between the engineers in smart building and student from the art department will take place to give more interest to the projects of both students. This will also increase acceptability by inhabitants of solutions for home automation too.

In France the studies to become engineer last 5 years after A-level. Our course correspond to the 3 last years, it has an

academic duration of 1800 hours. It addresses to student having a scientific diploma general or specialized, in this way, we respect CTI's recommendations [7], the French engineering agency for the accreditation of engineering curricula.

The first year of the course gives the students strong skills in mathematics, automation, computer science and thermal. These skills will allow them to understand the more specific courses of the last two years, but will also give them opportunities to reorient their career after some years if they want to.

We will give details of the last two years (see Figure 2 and Figure 3) corresponding to the Masters 'Degree. During the last year of this master degree student will make a trainee in enterprise, it is the reason why the number of hours of lecture, tutorial and practical work is reduced.

1st Year Master Program	Time with students (hours)
	Lecture, tutorial, practical work
Applied mathematics	
Optimization and Operations Research	50
Information theory (channel, modulation, Fourier modes)	50
	100
Electrical integration and local area network	
Networks and protocols	50
Web services	50
Electricity generation and stocking	50
EMC : guided and radiated modes, emission and hypersensitivity	50
Project	
	200
Water and Energy	
Renewable and Alternative energy	50
Ecodesign of habitat	50
Thermoregulation	50
Water management	50
Project	
	200
Project management	
Team management tools	20
Safety engineering	20
Project management	30
	70
Human, Economic, Management, Language Sciences	

Carrier plan	6
Human resources	8
Labour law	6
Business law	6
Environmental management	10
Information technology law	12
English language	112
	160
Total Number of hours per student	730

Figure 2. First Year of Master Program

In the last year of the course, students have to realize an industrial project, so the hours of academic teaching are reduced.

2nd year of the Master Program	Time in front of students
	Lecture, tutorial, practical work
Process Control, man-machine cooperation	
Process control, Field bus, Human-computer interaction	50
Image and information analysis and processing	50
Standards : Advantages and aims illustrated by application	50
Project	
	150
Integration	
Arrangement of housing spaces. Architectural typology	50
Housing accessibility, interior architecture	50
Construction, urbanism and environment law	50
Sensorial Design applied to materials, Design and structure of habitat	50
Project	
	200
Human, Economic, Management, Language Sciences	
Career plant approval	6
Interview preparation	4
Human resources	8
Economics and management – strategy	16
Economics and management – marketing	12

Economics and management - business plan	8
English language	66
	120
Number of hours per student	470

Figure 3. Second year of Master program without the final trainee

There are many small projects included in each of the thematic courses, this is necessary, because we want that the students really become implied in each part of the curriculum and not only consumers of the course.

5.2 Differences with other curricula dealing with sustainable buildings

In France, from 2 years, the schools of engineers feel concerned by the problematic of energetic efficiency for buildings.

In our school, two approaches started from demarches of the electronic department in front of a necessity to evolve or die!

So the two approaches that we realized in Polytech Orléans are electronic oriented:

-designing the new course presented here, completely devoted to smart building,

-creation an option of last year in the classical electronic (now called eco-technology) course

While in other schools [6] they started from civil engineering adding teachings in electronics.

The two categories of engineers will have to work together, but engineers whose basic skills are electronic will be able to go deeper in technologic solutions for home automation. Our approach driven by enterprise and attractiveness problematic is coherent with our site strategy; a cluster called S2E2 (Sciences et Systèmes de l'Energie Electrique) is present in Région Centre and develops transversal solutions and experimental platforms from electronics solutions applied to buildings.

6. CONCLUSIONS

A problem occurred at the time of the accreditation by Commission des Titres d' Ingénieurs. This agency wishes that the title of engineering courses refer to great domains of engineering (American classification of ABET). In our case it is rather impossible because we depend both of two of these fields. After a discussion between the school and the agency, the decision was to keep the name "intelligence of building" for 3 years and to decide what to do on the next accreditation process. The dean of the school thinks that those multidisciplinary courses are necessary to generate innovation and we hope that some of the engineers will decide to create enterprises in these fields.

Concerning the attraction of students, it quickly proved to be a good bet, as soon as the information about the new accreditation was broadcast, many students came with a candidature.

In the fields of engineering such as electronic engineering, attract the student is one thing, keep their interest is another one; the organization of the teachings in units where the mathematics

necessary to the study of signal treatment is placed with the applications of those mathematics is a good thing; at these moments we have a strong interest about the use of apprenticeship by problem learning. People from University of Leuven [8] came to explain to the teachers the concepts and interest of this methodology, the final evaluation of this session showed a real interest of the teachers.

Concerning enterprises, we hope that the crisis will let them propose internships to the students. We were very happy to see that those enterprises took time to meet the CTI agency when it comes in the school to make an audit before deciding to accredit ate the course. The pertinent explanations of these enterprises (Wirecom, Legrand) were the best keys to show what were this curriculum concept and the real need for it.

At the same time as we designed this curriculum, the ministry of education decided to change the secondary technical course that closes secondary scholarship and leads to the University: instead of a specific course for example: electronics, power electronics, they decided to create a more transversal teaching including principles of sustainable development. In a certain way, this point of view is very similar to the one that guided the design of our curriculum. At each level, electronics and electrical engineering need to attract good students that would be able to realize postgraduate studies [9].

The complete program can be found on our web site [10], the course open in September 2011.

We consider that the methodology used in this curriculum is convenient and necessary in other fields of teaching science and technology, the approaches quoted in [9] confirm it.

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