

# Enhancing Engineering Competencies Curricula in the Context of University-Industry Chairs

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**Abstract**—University-industry Chairs can play a key role to enhance the acquisition of certain curricular competencies of the Engineering Degrees such as teamwork capability, oral and written communication skills, entrepreneurship initiative and industrial environment knowledge, all of them highly valued and long demanded by the industrial companies. This paper describes the organizational framework and the main programs of the Chair of Renewable Energies of the Public University of Navarre and evaluates how it is contributing effectively to improving the acquisition of these competencies and skills.

**Keywords**—university-industry collaboration, university Chairs, engineering curricular competencies, company internships

## I. INTRODUCTION

The preparation of students to enter the labour market with a competitive academic curriculum is one of the main objectives of the European Higher Education Area (EHEA), especially in engineering degrees. In a context of global industrialization, collaboration between universities and industry can make it possible to develop programmes and activities that improve and promote the acquisition by engineering students of certain curricular competencies that are difficult to acquire solely with the teaching activities carried out on university campuses [1]-[4].

In this sense, the university-industry chairs represent one of the best frameworks to design specific activities throughout the engineering degrees that can take place both at the university and in the companies' own facilities and that can be carried out with the collaboration of the engineers of these companies [5], [6]. Chairs can also be particularly beneficial for companies, as these initiatives:

- Increase their visibility among students, thus forming the best pool of possible future workers.
- Allow them to improve their brand image in the society by collaborating in the academic training of students.

- Provide an easy and fast way to get to know the research groups of universities and cooperate on new projects.
- Represent a privileged communication channel that allows them to access the university world preferentially, gaining competitiveness over other companies.

This article describes in detail the experience of the Chair of Renewable Energies of the Higher Technical School of Industrial and ICT Engineering of the Public University of Navarre (UPNA, Spain). Navarre is one of the most industrialized regions in Spain and concentrates some of the most important engineering and R+D centres of several international renewable energy companies. Within the UPNA, this School is the largest one by number of students and collaboration projects with companies. In the School, the main Engineering Degrees and Master's Programs of the University are taught.

The Chair of Renewable Energies, by far the largest of the university, is integrated, besides the university, by seven of the main entities of the renewable energy sector of Navarre (Siemens Gamesa Renewable Energy, Ingeteam, Acciona Energia, Nordex, Array STI Norland, EOSOL and IED Electronics) and an international reference technology centre (CENER, National Centre for Renewable Energy).

The Chair was founded in 2010 and in its 13 years of life it has become a benchmark for the chairs of both the UPNA and other universities. This paper describes first in Section II the context of the Chair. Then, Section III introduces its organizational and administrative framework. Subsequently, Section IV presents the four main programs of the Chair and briefly describes them. The programs are assessed in Section V, where it is detailed how they influence the curricular development of undergraduate and graduate students throughout their degrees, what competencies and skills they work and how they are improved. Finally, the main conclusions of the paper are summarized.

## II. CONTEXT

In order to subsequently analyze and assess the impact of the programs launched by the Chair of Renewable Energies, it is important to know the context in which they are carried out, and in particular, the characteristics of both the existing industrial environment in the region and the university itself.

Navarre is a region located in the north of Spain with a very powerful industrial sector that represents approximately 30% of its GDP and where renewable energies and automotive companies have a great weight. It is also a highly exporting region, mainly to France, Germany, and other countries of the European Union. The region has many wind farms and photovoltaic plants, producing approximately 80% of its electricity with renewables in annual terms.

The university is the main educational institution of the region and has about 9000 students and almost 1200 professors. The Higher Technical School of Industrial and ICT Engineering is the main School and offers six four-year degrees in Industrial, Mechanical, Electrical, Computer Science, Telecommunications and Biomedical Engineering, as well as various Master's Programs in Industrial Engineering, Renewable Energies, Computational Mechanics, Materials, Telecommunications and Computer Science. The School has played a fundamental role in the implementation and growth of renewable energy companies in Navarre, since the engineers of these companies are, for the most part, graduates in one of the engineering degrees, with percentages that reach 90% in some departments.

Finally, it has to be mentioned that the School's degrees have been awarded with the EUR-ACE accreditation, an engineering quality label recognized across Europe [7]. The collaboration with industry, such as the one performed within the framework of the Chair of Renewable Energies, has been one of the key factors to achieve this recognition, according to the EUR-ACE accreditation committee.

## III. ORGANIZATIONAL FRAMEWORK OF THE CHAIR

As shown in Fig. 1, the UPNA Chair of Renewable Energies is organized around two bodies, namely the Steering Committee and the Management Team, in accordance with the provisions of the Framework Collaboration Agreement. At the administrative level, the Chair has the support of the university Research Service and the School Administrative Unit. In addition, the Chair also collaborates with the University-Society Foundation, particularly within the Program of Company Internships for undergraduate students.

The Steering Committee is made up, in equal parts, of representatives of the entities and professors appointed by the Vice-Rector for Research. The Management Team is formed by the Director of the Chair, the Deputy Director, and the Technical Secretary. The Director is appointed by the Vice-Rector for Research, and then the Deputy Director and the Technical Secretary are appointed by the Director.

The Committee approves the annual activities and the budget, and the Management Team executes them. The entities have effective control of the operation of the Chair through the Steering Committee. In addition, through the Director of the Chair, they also have a permanent and privileged communication channel that allows them to participate in degree commissions, institutional events, internship programs, search for experts, collaborative projects, etc.

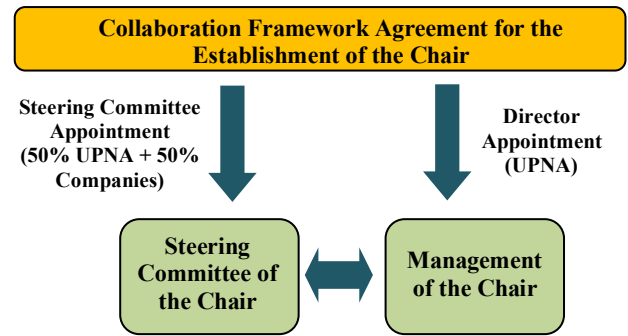


Fig. 1. Management framework for the Chair.

## IV. PROGRAMS OF THE CHAIR

### A. The Programs and their roadmap

As indicated above, one of the main objectives of the Chair is to promote and enhance the acquisition of competencies by engineering students, and thus contribute to improving their skills, curriculum and employability for their professional future. In this sense, the Chair has four main Programs, which are described in this Section. The Programs are:

- 1) *Program of Visits to Production Facilities and Engineering and R&D Centers*
- 2) *Program of Company Internships and Final Degree Projects for undergraduate students*
- 3) *Energy Week and Renewable Challenge*
- 4) *Program of Master's Thesis at Companies for graduate students*

Although the Programs are offered for several engineering degrees of the School, their highest impact is on the industrial engineering degrees, namely the Degree in Engineering in Industrial Technologies and the Master's Program in Industrial Engineering. It has to be mentioned that most of the students that finish this Degree continue their studies with this Master's Program. Table I shows the roadmap of the Programs along these two degrees, particularly the years when they are offered or when they have activities that the students can enrol in. As can be seen, while the *Program of Visits to Production Facilities* is offered every year from second year, the rest is offered only for a particular year. The *Program of Company Internships and Final Degree Projects* is offered for the undergraduate students of the last year, the *Energy Week and Renewable Challenge* is offered for the first-year students of the Master's Program, and the *Program of Master's Thesis at Companies* is offered only for the last-year students of the Master's Program.

The roadmap of Table I has been carefully designed to progressively bring students closer to the companies and entities of the Chair. In addition to enhancing the acquisition of competencies and skills, the roadmap tries to promote the realization of Master's Thesis in the companies of the Chair, which is one of the main objectives of the Chair, and thus facilitate the recruitment of students by the companies.

Some of the programs have been running since the beginning of the Chair, thirteen years ago. This is the case of the *Program of Visits to Production Facilities* and the *Program of Master's Thesis*. On the other hand, the *Energy Week and Renewable Challenge* has been running for ten years so far, and the *Program of Company Internships* for

undergraduate students was started two years ago. The assessment of the programs, including their main figures and the competencies and skills they enhance will be detailed in the following Section.

TABLE I. ROADMAP OF THE CHAIR'S PROGRAMS

Programs	Degree in Eng. in Ind. Technologies				Master in Ind. Eng.	
	1 <sup>st</sup> year	2 <sup>nd</sup> year	3 <sup>rd</sup> year	4 <sup>th</sup> year	1 <sup>st</sup> year	2 <sup>nd</sup> year
Program of Visits to Production Facilities						
Program of Company Internships and Final Degree Projects for undergraduate students						
Energy Week and Renewable Challenge						
Program of Master's Thesis at Companies for graduate students						

### B. Program of Visits to Production Facilities and Engineering and R&D Centers

In this program, students make visits to production facilities of the entities of the Chair within the framework of advanced technological courses in which it is necessary to work on skills associated with the design and industrial manufacture of products for renewable energies. Likewise, these visits bring students closer to the work market since they allow them to know the day to day of a company in which they could join once they finish their studies. This program is developed both in the last years of the Degrees, and in the two years of the Master's Programs.

The program is updated each year at the beginning of the year. Mostly, the program is offered to the teachers of the subjects related to renewable energies. Once it is known in which subjects the program is going to be carried out, the visits are ordered chronologically according to the characteristics of both the subjects in which they are carried out and the facilities that are visited. At the end of the Master's Programs, the Chair guarantees that all students have been able to visit at least five facilities of the entities of the Chair, being at least one of them a productive facility, another one a renewable power plant and another one a R&D laboratory.

### C. Program of Company Internships and Final Degree Projects for undergraduate students

This program offers specific company internships for students in their final year of their degree. This is the youngest program of the Chair and was launched at the request of the companies of the Chair to try to improve their options for hiring students graduated in engineering who were not interested in continuing with a Master's Program. For this reason, the program is offered specially to the last-year students of the Degrees in Electrical Engineering and Mechanical Engineering. Unlike the students of the Degree in Engineering in Industrial Technologies, these students hardly continue studying a Master's Program.

In this program, the companies of the Chair offer certain number of internships, then students apply for the ones that interest them most in order of priority, and finally the companies, with the help of the Chair, select the suitable students for each internship. The internship is carried out

entirely in the company although with the help of a supervisor from the university. The reason is that, at the same time as the internship, the student carries out his Final Degree Project in the same subject as the work done during the internship.

### D. Energy Week and Renewable Challenge

This activity is carried out annually for first-year Master's students. It is one of the activities that has the most media impact. It takes place over the course of a week in the spring semester. It has two parts. In the first, engineers from the renewable companies of the Chair give various workshops and conferences to students in which they present their companies and describe examples of projects in which they have participated or are participating.

In the second part, called Renewable Challenge, a team competition is held that lasts 24 consecutive hours and in which the teams have to make proposals to solve a challenge which is kept secret until the start of the competition. After the 24 hours, they defend the proposals before a committee composed of engineers from the entities of the Chair that awards a first prize and an accessit.

### E. Program of Master's Thesis at Companies for graduate students

At a formative level, this is the main program of the Chair. Although more figures will be given in the next Section, it can be anticipated that more than a third of the students of the Master's Programs in the field of industrial engineering and renewables participate in the program. In this program, with the collaboration of the entities, a number of projects for Master's Thesis is offered to be carried out in the companies of the Chair. The projects are technology related to the products and systems that the companies design and manufacture. Students have two supervisors, one from the company and the other from the university, and throughout the program they work on the competencies associated with the Master's Thesis and the stay in the company. The final evaluation of the students reaches values well above the rest of the students of the School, and the employability rate of these students in the companies of the Chair is close to 100% once they finish their Master's Thesis.

Since this is the oldest and most important program of the Chair, the stages in which it is organized are well defined:

#### 1) Configuration of the project offer

In this first stage, the companies propose a first set of projects that is filtered and reviewed by the Chair. For each project finally offered, a file is prepared with the title of the project, a brief description, the Master's Program(s) to which it is addressed and, where appropriate, the degree that the student who wants to opt for that project has had to study.

#### 2) Selection of the university and company supervisors

As mentioned above, each project has two supervisors, one from the university and one from the company. In this way, it is guaranteed that the students have permanent support in their day-to-day work in the company, but also has the support of a supervisor at the university to solve technical doubts and organize the work related to his Master's Thesis.

#### 3) Approval of the project offer by the Steering Committee and application period

Finally, the Steering Committee approves the offer of projects, including the supervisors of the companies and the university, and launches the corresponding call to the students

of the affected Master's Programs. This opens a period in which students can consult the project files, resolve any doubt they have with the supervisors and finally apply for projects they are interested in order of priority.

#### 4) Project assignment

Each student attaches to their application a brief CV and the academic records of both the previous degree they have completed and the Master's Program they are studying. The Chair organizes this information and, through a joint committee formed by the Government Team of the Chair and representatives of the companies, the applications are evaluated according to their CV, academic profile and project priorities, and finally the appropriate student is selected for each project

#### 5) Development of projects

At the end of the period of assignment, students sign the acceptance of the projects and the corresponding confidentiality clauses. Subsequently, project launch meetings are held in each entity and students begin to work on their projects. At the end of the semester, students defend their Master's Thesis carried out within the framework of their projects before a tribunal formed by professors of the School and, eventually, engineers of the companies.

The first two stages usually take place in October. The third stage takes place in November and the fourth one in December. In January the students sign the acceptance of the projects and, finally, in February the projects start after the corresponding kick-off meetings. The projects run from February to June and the defense of the Master's Thesis usually takes place at the end of June.

## V. PROGRAMS ASSESSMENT

Taking into account the number of students and professors involved, the satisfaction surveys carried out to companies and students, and the grades obtained in the programs in which there are evaluable activities, it can be considered that the four programs of the Chair are working satisfactory.

As mentioned above, one of the main objectives of the programs is to help the students work and acquire various competencies of the Degrees and Master's Programs in Engineering. Table II shows the competencies, both at Degree level (for undergraduate students) and at Master level (for graduate students) that the activities of the programs try to enhance. It also indicates the level of enhancement of the competencies (very high, high, medium, low) achieved with each program, according to the average opinion expressed by the participants in the programs (teachers, students, company workers and Management Team of the Chair). These competencies represent around 80% of the general competencies of the aforementioned Engineering Degrees and Master's Programs.

As expected, the first two programs are specially related to undergraduate competencies, while the other two are related to graduate competencies. The *Program of Company Internships for undergraduate students* is especially useful when it comes to promoting the acquisition of competencies related to working in industrial environments, decision-making, personal initiative, ability to work in multidisciplinary environments and ability to develop and defend an engineering project, the latter related to the fact that the program includes the completion of the Final Degree Project.

TABLE II. ASSESSMENT OF THE CHAIR PROGRAMS: ENHANCEMENT OF UNDERGRADUATE AND POSTGRADUATE ENGINEERING COMPETENCIES

Competencies <sup>a</sup>		<i>Program of Visits to Production Facilities</i>	<i>Program of Company Internships and Final Degree Projects</i>	<i>Energy Week and Renewable Challenge</i>	<i>Program of Master's Thesis at Companies for graduate students</i>
Undergraduate competencies (Degree level)	CG1: Ability to develop and complete industrial engineering projects.		+++		
	CG2: Knowledge of basic and technological subjects to have the ability to learn new methods and theories, and versatility to adapt to new situations.	++	++		
	CG3: Problem solving proficiency with personal initiative, decision making, creativity and critical reasoning.		+++		
	CG4: Ability to elaborate and communicate knowledge, abilities and skills in industrial engineering.		+		
	CG5: Ability to analyse and assess the social and environmental impact of technical solutions.	+	+		
	CG6: Organizational and planning capacity at company level, as well as other institutions and organizations.	+++	+++		
	CG7: Ability to work in a multidisciplinary environment.		+++		
	CG8: Ability to realize, present and defend the results of an individual engineering work before a university tribunal at undergraduate level.		++++		
Graduate competencies (Master level)	CM1: Possess and understand knowledge that provides a basis or opportunity to be original in the development and/or application of ideas.	+		++	++
	CM2: Ability to apply the acquired knowledge and solve problems in new or unfamiliar environments within broader (or multidisciplinary) contexts related to their area of study.	+		++	+++
	CM3: Ability to integrate knowledge and face the complexity of making judgments based on information that, being incomplete or limited, include reflections on social and ethical responsibilities.			++	+++
	CM4: Ability to communicate conclusions and knowledge, and ultimate reasons that support them to specialized and non-specialized audiences in a clear and unambiguous way.			+++	++++
	CM5: Ability to realize, present and defend the results of an individual work before a university tribunal, consisting of a comprehensive project of Industrial Engineering at a Master level.				++++

<sup>a</sup> Level of enhancement: ++++ (very high); +++ (high); ++ (medium); + (low)



The importance of the *Program of Master's Thesis for graduate students* is clear when it is observed that it enhances all the competencies at Master level. Specially, this program is useful to promote abilities related to solve problems in broader contexts, communicating conclusions and knowledge to specialized and non-specialized audiences and carry out and defend a Master's Thesis. Finally, the *Energy Week and Renewable Challenge* is offered at Master level and works on the similar abilities as the previous one but to a lesser extent.

When the programs are analyzed in terms of the skills they work, the results are shown in Table III. As can be seen, the programs promote technical skills, efficient teamwork, self-confidence, self-control, efficient oral & written communication, problem-solving skills, initiative & creativity, ability to perform an original professional work in the renewable energies area, etc.

TABLE III. ASSESSMENT OF THE CHAIR PROGRAMS: SKILLS

Skills <sup>a</sup>	Program of Visits to Production Facilities	Program of Company Internships and Final Degree Projects	Energy Week and Renewable Challenge	Program of Master's Thesis at Companies for graduate students
Technical skills		+++		+++
Motivation	+	+	++	+
Responsibility		+		++
Self-confidence		++		++
Self-control		+	++	+
Positive attitude	+	++	+	++
Stress management		+++	++++	+++
Initiative and creativity	+	+++	++++	+++
Problem solving skills		++	+++	++
Work planning and organization	++	+++	+	+++
Empathy			+++	
Team work skills			++++	
Flexibility		+	+++	+
Leadership		++	+	++
Communication skills		++	+++	+++

<sup>a</sup> Level of enhancement: ++++ (very high); +++ (high); ++ (medium); + (low)

The participation in the different programs is very high. Concerning the *Program of Visits to Production Facilities*, it can be estimated that, on average, more than 80% of students of industrial engineering degrees participate in the program and, at the end of their degrees, have visited around 7-8 production and renewable facilities. In the case of the graduate students enrolled in a Master's Program, particularly in the Master's Program in Industrial Engineering, nearly all the students visit, at least, 2 facilities, and the students doing the specialization in renewable energies visit around 4 additional facilities. These figures show that the program is meeting its goal of reaching at least 5 visits to production facilities and R+D centers. The figures do not include the period of the covid pandemic, during which it was not possible to make visits to the facilities due to health restrictions.

Concerning the *Energy Week and Renewable Challenge*, nearly all the students of the Master's Program in Industrial Engineering are involved every year. Throughout the 10 years of the program, around 60 conferences have been given by professionals from the companies of the Chair. The Renewable Challenge changes every year and tries to deal

with current issues. Some examples of the previous years are "UPNA GREEN: a Campus for the 21<sup>st</sup> century", "Urgent decarbonisation plan for Navarra by 2027", "Storage 2030: large-scale energy storage plan", "Smart Campus", "Electric and sustainable mobility plan for Pamplona" and "Design of integral energy supply system for residential housing". Fig. 2 shows the participants in the tenth edition, all of them students of the Master's Programs in Industrial Engineering and Renewable Energies, and Fig. 3 shows an example of a group working on its challenge.



Fig. 2. Energy Week and Renewable Challenge: participants in the tenth edition.



Fig. 3. Energy Week and Renewable Challenge: a group working on their renewable challenge.

As mentioned before, the *Program of Master's Thesis at Companies for graduate students* is the most important at a formative level. Table IV shows the main figures concerning projects offered, students applying, and projects assigned, in the last six years. The number of projects offered by the companies of the Chair has increased over the years, except for the year of the covid pandemic. The number of students who apply for the projects has also increased very quickly, growing from 17 to 38 in these six years. Most of these students are doing the Master's Program in Industrial Engineering or the Master's Program in Renewable Energies. It can be estimated that around 35% of the students of the Master's Program in Industrial Engineering and 50% of the one in Renewable Energies apply for the projects offered by the Chair.

As expected, the number of projects assigned has also grown. It is important to note that in the last year nearly all students have obtained a project, given the high number of projects offered. In any case, the percentage of projects assigned is around 80%, with years in which it even fell to close to 50%. The goal of the Chair is to cover nearly all the projects offered, but this is difficult since it depends on the

number of students applying and their background, and particularly their specialization, in relation to the projects.

As explained before, the projects include the realization of the Master's Thesis and its defense before a tribunal made up of professors of the School. The average score of the thesis is shown in Table V. The score is in a scale from 0 to 10, being 10 the highest score. This is the Spanish scale, where scores below 5 are failed, between 5 and 7 are passed, between 7 and 9 are remarkable and above 9 are outstanding. As shown in the Table, the average scores obtained by the Master's Theses of the Chair over the years are very high, always above 9. They are also clearly above the average score of the Master's Theses of the School. The main reasons are that these theses are technically well defined, there is a previous selection of the students, the projects have a company supervisor and a School supervisor, and they have the permanent support of the company and the Chair.

At the end of the thesis, the employability of the students in the companies of the Chair is close to 100%. For all these reasons, this program has been consolidated as one of the most valued by the students of the School.

The program has also been assessed by means of satisfaction surveys to the students participating. Average results in the last years are shown in Table VI. As shown, the students are specially satisfied with the involvement of both the company and the company tutor, as well as with the compliance with the initial objectives. The surveys also indicate that the satisfaction is somewhat smaller with the involvement of the university tutor and the management. Probably, the reasons for that are related to the fact that the projects are carried out at the company facilities and not at the university, which somehow distances the student from the university in daily work. In any case, overall satisfaction with the program reaches a score of 9.0.

TABLE IV. FACTS AND RESULTS OF THE PROGRAM OF MASTER'S THESIS AT COMPANIES: PROJECTS OFFERED AND ASSIGNED

Facts	Academic year					
	17/18	18/19	19/20	20/21	21/22	22/23
Projects offered	19	24	30	22	32	46
Students applying	17	22	22	36	35	38
Projects assigned	11	17	16	19	28	37
Applications per offered project	0.89	0.92	0.73	1.63	1.09	0.82
Assigned projects per application	0.65	0.77	0.73	0.53	0.8	0.98
Ratio assigned / offered projects	58%	71%	53%	86%	87%	80%

TABLE V. FACTS AND RESULTS OF THE PROGRAM OF MASTER'S THESIS AT COMPANIES: FINAL SCORE OF THE THESIS

Facts	Academic year					
	16/17	17/18	18/19	19/20	20/21	21/22
Average score (out of 10, being 10 the highest score)	9.2	9.4	9.5	9.6	9.5	9.1

TABLE VI. FACTS AND RESULTS OF THE PROGRAM OF MASTER'S THESIS AT COMPANIES: SATISFACTION SURVEYS

Questions	Results (out of 10, being 10 the highest score)
Involvement of the company tutor with the MT <sup>a</sup>	8.8
Involvement of the company with the MT <sup>a</sup>	9.2
Involvement of the UPNA tutor with the MT <sup>a</sup>	7.4
Level of compliance with the initial objectives MT <sup>a</sup>	9.4
Satisfaction with the management of the Program	7.1
General satisfaction with the completion of the MT <sup>a</sup>	9.0

<sup>a</sup>. MT: Master's Thesis

Finally, it has to be mentioned that the *Program of Company Internships and Final Degree Project* has been running for only two years, and therefore the necessary information for a complete evaluation of the program is not yet available.

## VI. CONCLUSIONS

This paper describes the experience of the Chair of Renewable Energies of the Public University of Navarre and, particularly, the role that has played since it was founded in 2010 in enhancing the acquisition of certain competencies and skills by the students of the engineering Degrees and Master's Programs of the Higher Technical School of Industrial and ICT Engineering. The Chair has four main programs organized on a roadmap along the engineering studies to guarantee that nearly all the engineering students can take advantage of them. The four programs are the Program of Visits to Production Facilities and Engineering and R&D Centers, the Program of Company Internships and Final Degree Projects for undergraduate students, the Energy Week and Renewable Challenge, and the Program of Master's Thesis at Companies for graduate students. The article shows the main figures to date of the programs, as well as the impact they are having on the acquisition of competencies.

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