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Enhancing the Development of Multidisciplinary Skills in Engineering Students by Promoting Industry and University Synergy*

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In this paper, the development of different multidisciplinary skills within the framework of development of Final Degree Projects and Master Degree Projects is presented. By means of liaisons established with industry, not only technical aspects of real industrial challenges are covered, but also the necessary transverse competences. The continuous feedback between students, academia and industrial/corporate members leads to an effective multidisciplinary environment, in which all of the participants have the opportunity of experiencing an effective increase in their knowledge base.

Keywords: engineering education; European Higher Education Area (EHEA); Final Degree Project; Master Degree Project

1. Introduction

One of the main challenges that academics as well as students have to face is the preparation in order to promote successful introduction in the work environment. Companies have to compete in a globalized environment, requiring highly skilled and motivated newly graduates. Not only large corporations, but an increasing amount of Small and Medium Enterprises (SMEs) have the need of creating multidisciplinary and project oriented work teams in order to effectively compete. It is therefore compulsory to aid students in the adoption of transversal competences, with a clear focus on group skills, project based development and broad technological and market vision. Such competences fall within the framework of European Higher Education Area (EHEA), in which the vision of Industry plays a key role in their definition, with aim of increasing competitiveness.

In the case of Engineering Degrees, multidisciplinary approaches to problem solving have become a requirement in the curricular development of students. Besides the traditional analytical, numerical and phenomenological tools developed in initial courses, new competences gain relevance. The development of case studies or project-based courses and assignments are being widely adopted in order to emphasize the desired competences.

Another element in which such skills can be developed is the preparation of final degree projects and Master Thesis. Due to the characteristics of engineering projects, the topics and the development of these can be closely related with industrial needs, not only on the technical side but also in the management as well as economic related issues of such projects. In order to increase the interest as well as the applicability of these projects, feedback from Industry partners is compulsory.

In this work, we will present the development of different types of Final Degree and Masters Degree projects, in which industrial feedback is employed in order to increase the achievement levels of all of the desired competences, especially transverse ones. Due to the fact that up to date knowledge from industry is necessary at a technical level as well as in terms of corporate requirements for potential employees, active collaboration in the definition as well as in the execution of these projects is sought. Therefore, one of the key elements in this process is to establish and maintain University-Industry liaisons in the framework of the Final Degree/ Master's Degree projects. In order to achieve such liaisons, two approaches have been followed: contacts between faculty and industry and the establishment of an official liaison known as the Renewable Energy Class. This later initiative is based on long term cooperation between a group of companies related with the Renewable Energy sector and the Industrial and Telecommunications Engineering School at the Public University of Navarra. This provides a natural commonplace in order to identify industrial needs and propose specific projects to offer final year engineering students, both at a Graduate level as well as in Masters level, as depicted in Fig. 1. Close interaction is established between work staff in the companies, the students and the faculty that is mentoring these projects, which enables a clear roadmap to fulfill the required competences. The experience is demonstrating the

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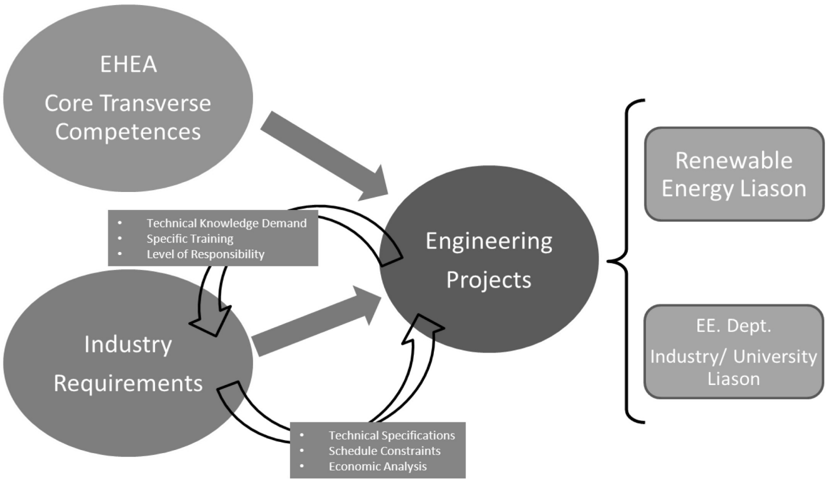

Fig. 1. Schematic representation of the Development of Final Degree/Master's Degree projects within the Industry-Academia synergic environment.

benefit of such synergic approach, both enabling students to achieve the desired training and skills to work in a multidisciplinary environment and companies to perform a more efficient incorporation of their future personnel.

The paper has been organized in four sections. Section 2 describes the context in which this work is carried out. Section 3 describes the different initiatives as well as the assessment results. Finally, conclusions in Section 4 close this paper.

2. Teaching-learning methodology

In this section, the context in which the learning process analysis is carried out, within EHEA will be described, with focus on the framework in the Industrial and Telecommunication Engineering School at the Public University of Navarra and the University of Vigo.

2.1 Employability as aimed effective outcome of the Bologna Process

The 2012 Bologna Process Implementation Report [1] stated that access to higher education is not enough as an objective of the Bologna Process and that it is also required looking at the effective outcomes to assess the effectiveness and progress of the process implantation. Generally speaking, all the data analysis point towards large differences between EHEA countries.

The outcome of higher education is then measured in [2] by attainment and completion rates as well as by the labour market prospects of graduates, i.e. in terms of employability. Completion rates are monitored at national and /or institutional levels in most countries. This data is used for the preparation of annual statistics, efficiency analyses, admission planning and dialogue with the stakeholders.

As indicated in [1], employability has been one of the central goals of the Bologna Process from the very beginning, which resulted from a concern about graduate unemployment and it was also related to the emergence of a European labour market. In May 2007 the Bologna Follow Up Group was called to consider in more detail how to improve employability in relation to the three cycles in higher education as well as in the context of lifelong learning. As a result, a Working Group on Employability was established to examine evidence and to make suggestions in order to point out likely improvements for the employability of graduates.

A report [2] was elaborated as a result of deliberations of the Working Group on Employability over four meetings from October 2007 to January 2009, containing important reflections to work on. Most of them rely on the idea of developing practical suggestions for encouraging further dialogue between employers and higher education institutions. Here are some of those ideas:

- some suggestions for actions to be taken by governments, higher education institutions and students in the area of employability;
- awareness-raising amongst employers of the value of a Bachelors qualification and associated learning outcomes;
- involving employers in devising curricula and curriculum innovation based on learning outcomes;
- work experience is highly valued by employers. Young graduates who finish studying with work experience tend to be more competitive in the labour market than those who do not.

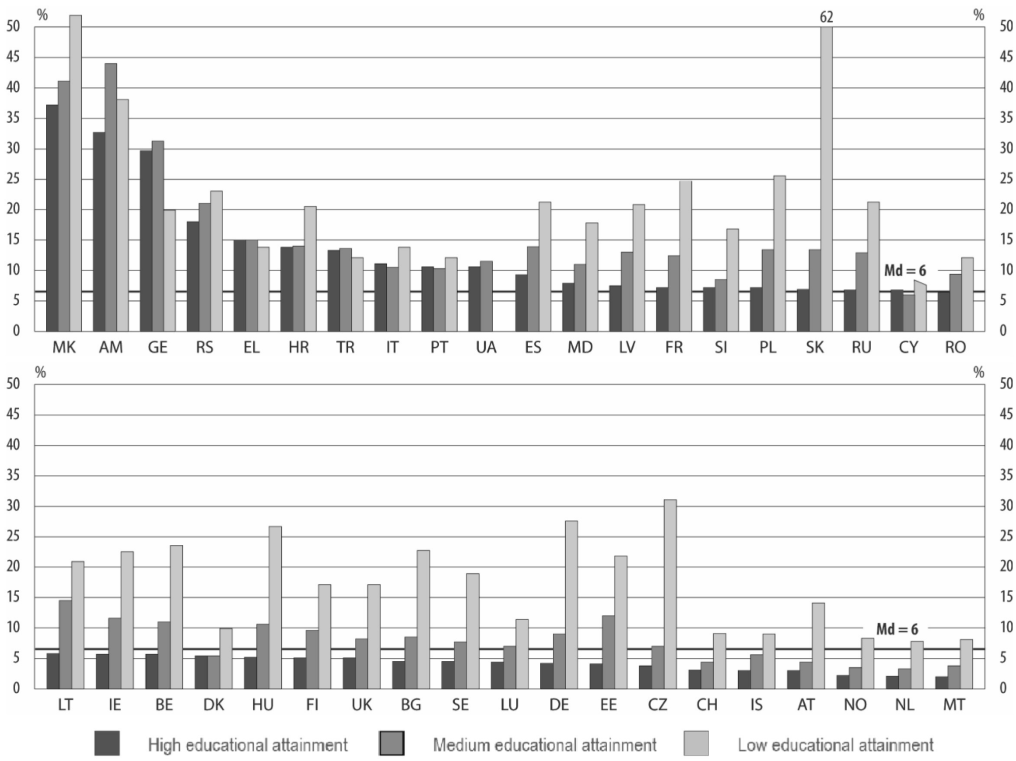

Fig. 2. Unemployment ratio of people aged 20–34 by educational attainment level (%), average 2006–201 (Source: [1]).

Taking up some of the recommendations of the Working Group on Employability report [1], the Bologna Follow Up Group in 2009 emphasised the need for, "close cooperation between governments, higher education institutions, social partners and students" in "maintaining and renewing a skilled workforce" [1, 2]. The report [1] highlighted that higher education institutions should be more responsive to employers' needs, and also emphasised the importance of work placements and on-the-job training [1, 2].

Then, as per [1, 2], within the Bologna Process, employability is understood as "the ability to gain initial meaningful employment, or to become self-employed, to maintain employment, and to be able to move around within the labour market" [2]. In this context, the role of higher education is "to equip students with the knowledge, skills and competences that they need in the workplace and that employers require; and to ensure that people have more opportunities to maintain or renew those skills and attributes throughout their working lives" [2].

According to the conceptualisation of the Working Group on Employability described in [1, 2], the unemployment ratios of tertiary education graduates can give indications about the labour market prospects of educated young people, showing the tertiary education graduates' ability to gain initial (and meaningful) employment.

Figure 2 extracted from [1] shows the unemployment ratio of persons aged 20–34 by educational attainment level; however, only the average of the years 2006–2010 is presented, making it not possible to analyse the employment prospects of graduates in the light of recent economic changes.

From 2012 Bologna Process Implementation Report [1], it is concluded that:

1. On average, the higher the level of education, the lower the unemployment ratio of young people. In half of the EHEA countries, the unemployment ratio of young people with low educational attainment (at most lower secondary education) is higher than 19%. The median ratio is 10.6% for the medium educated (at most post-secondary non-tertiary education) and only 6.4 % for young people with a tertiary qualification.
2. Similarly, persons with high educational attainment find their first job position faster than the group of people with only secondary education and they also earn more on average. However, there are differences among tertiary education graduates: recent graduates can face difficulties entering the labour market.
3. Furthermore, around 20 % of graduates can be regarded as over-qualified for the job in which they are employed, with "services" graduates

being the most likely to be in this situation. This percentage has remained stable between 2000 and 2010, suggesting that over-qualification rates may be sign for transition problems between higher education and the labour market, and it may be influenced more by labour market structures and innovation than by the growing number of students.

4. While median ratios are almost identical for the two genders, on average, obtaining a higher qualification improves women's employment prospects more than that of men.

For a fair analysis of the data shown in [1], we should consider that since the time when the Working Group on Employability made its work, in some countries graduate unemployment is becoming an issue generally worsened due to the economic crisis which is an undeniable and important determinant of the availability and quality of job opportunities.

According to [1], however, a micro view interpretation of the graduate unemployment can possibly indicate a circumstance or factor which when combined with wider economic conditions may result in an oversupply of graduates in subjects where there was no immediate labour market demand. These circumstances are:

- Mismatch between the needs of employers and the content of courses offered by higher education institutions and selected by students.
- Graduate unemployment could also be due to the fact that their flexibility to be able to work in other related fields is not high enough.
- Another factor might be that the content of their courses did not focus on employability and labour market relevance.

It is then undeniable that the employers can provide valuable indicators on the labour market demands to be considered by the higher education sector for the preparation of careers and/or contents. The report by the Bologna Follow Up Group indicates four main challenges to overcome in order to achieve an effective dialogue between employers and high education institutions [1] in order to improve the employability and long-term training:

1. Ensure that the value of Bachelor programmes is clarified and communicated so that it is understood, particularly by employers, students, parents and academics/professors and higher education institutions themselves.
2. For individual higher education institutions and employers to engage in a meaningful two-way dialogue which allows institutions to be more responsive to employer and business needs and for employers to explain their needs better to institutions.
3. Encourage more employers to offer more high quality placements, for higher education institutions to integrate them sensitively within the curricula, and for students to view them as a key part of their course.
4. Improve provision of information, advice and guidance about future careers and employment opportunities for students.

The two main working lines pointed by the Bologna Follow Up Group in the field of employability in [1] are as following:

1. Promoting greater dialogue between higher education institutions and employers.

   Employers, both in public and private sector, and universities need to be encouraged to cooperate more to ensure that the skills that they feel graduates need are reflected in higher education provision. There is a need to encourage a more systematic dialogue between higher education institutions and employers at all levels—internationally, nationally, regionally and locally. This dialogue needs to take place across a wide range of different areas, including curriculum design, accreditation and/or quality assurance of programmes, work placements for students, preparation of professional standards, and transforming knowledge and research into practice.

   The Bologna Follow Up Group suggests.

   - that Governments should take the lead in ensuring the conditions which will promote and incentivise dialogue; and
   - that higher education institutions and their representative bodies should develop or strengthen links with employers and employer bodies (such as business and employers' associations, chambers of commerce, trade associations or professional groups) to establish partnerships to share good practice in how to make higher education provision more responsive to labour market demands and advise employers of the range of skills that graduates can bring to their employment.

2. Employability skills.

   Higher education institutions and employers need to work together, involving students, to identify ways in which courses and programmes of study can offer students the opportunity to develop and define for themselves the employability skills.

   The Bologna Follow Up Group suggests that there is an increased focus on providing work placements as part of courses; on students considering taking jobs related to their course of study where appropriate and which are compatible with their study work-load; on strengthening entrepreneurial skills in the curriculum; and on developing more programmes of part-time study to cater for those people already in the workplace who wish to update their skills as part of the lifelong learning agenda. Consideration should also be given to the interchange, through short work placements and secondments, between staff in business and staff in higher education institutions to overcome any barriers between them. Governments, the social partners, and higher education institutions should consider ways to increase such interchange.

3. Experiences in Seeking the Development of Multidisciplinary Skills.
   In this section, several experiences in which the search of multidisciplinary skills is sought will be described. These experiences are developed in two different regions in Spain (Galicia and Navarra), with approaches based on faculty-industry relations or in an institutional framework. This latter case is implemented via a Renewable Energy chair established with strong industrial actors in Navarra.

2.2 Characteristics of the practical practices at the University of Vigo: formalization of the Industry-University collaboration for an improved higher education purpose

By Royal Decree 1707/2011 of November 18th, external academic practices of college students were regulated. And the University of Vigo, under the said Royal Decree, passed in the session of the Governing Council of 24 May2012, the Regulation of Academic External Practices for Students of the University of Vigo. It was established the following general conditions to rule the professional practices for the students:

1. The professional practices subject to these regulations are made under the umbrella of the Educational Cooperation Program; the practices may be curricular or extracurricular, and even be the framework under which the Final Engineering Degree (FED) project is being carried.
2. The practical experience subject of the Educational Cooperation Program aims to professionally prepare university students in the operational areas of business to obtain professionals with a real view of the problems and facilitate their future incorporation into work in the society.
3. The particularity of the curriculum of the Engineering Degree in Telecommunication Technology(with specialization in the last two courses), and the fact that its memory defines this activity of practical experience as one stay in a company developing functions as an Technical Telecommunications engineer related to the professional profile(specialization) attended by students, advises recipients/applicants to make curricular practices have to overcome—or at least faced-a reasonable percentage of the curriculum specific to the specialization that they are studying. Consequently, it is required that the student has passed 24 credits of compulsory courses of the chosen specialization.
4. For curriculum practices, the validation in the Telecommunications Engineering Degree will be done in blocks of 6 ECTS, up to a maximum of 12 ECTS. The first block will require a minimum of 150 hours of work in the company, and the second will be achieved if it comes to 240 total hours. For extracurricular practices it will apply converting one ECTS credit for every 25 hours.
5. The FED can be developed in institutions or companies outside the University of Vigo, in the terms established in the institutional agreements signed. In that case the tutor in the company will act in a co-tutor role. The individually assigned academic tutor will share with the co-tutor the student's direction and guidance operations, and will be, in any case, the responsibility of academic tutoring for providing the management facility.

In the training program of the degree, it is indicated that the skills acquired by the student by means of the completion of his degree-end work, namely Final Engineering Degree project, are:

1. Specific competences:
   (a) CE90/TFG: Original exercise performed individually in order to be presented and defended to an assessment committee, consisting of a project in the field of Telecommunications Engineering specific technologies of professional level, which synthesizes and integrates the skills acquired during the learning stage.
   (b) All the competences common to the branch of Telecommunications.
   (c) All the competences relevant to the specialization attended by the student.
2. General skills:
   (a) CG1: Ability to draft, develop and sign projects in the field of Telecommunications Engineering, within the framework of expertise established in Order CIN/352/2009.
   (b) CG2: Knowledge, understanding and

ability to apply legislation during the development of the profession of Telecommunications Engineer, as well as capacity for managing specifications, regulations and mandatory standards.

(c) CG4: Ability to solve problems

  i. G4.1: Capacity to solve problems with initiative, decision making and creativity.
  ii. G4.2: Ability to communicate and transmit knowledge and skills.
  iii. G4.3: Capacity to understand the ethical and professional responsibility of Telecommunication Engineer activity.

(a) CG9: Communication skills

  i. G9.3: Ability to communicate both in writing and orally, knowledge, procedures, results and ideas related to the field of Telecommunications and electronics.

(b) CG14: Ability to use computer tools to search for library resources and information.

2.3 Context of the initiative at the Universidad Pública de Navarra

In this section, the context in which the initiatives proposed in this paper have been carried out is described. An overview is presented about relevant economical and societal facts of the region, the main characteristics of the University and the School of Engineering, and the degrees involved in the initiatives. This framework is important to understand the nature and impact of the approach and initiatives proposed in this paper.

A. The Region

Navarre, also officially known as the Chartered Community of Navarre, is an autonomous community in northern Spain, bordering La Rioja, the Basque Country, and Aragon in Spain and Aquitaine in France. It is a relatively small region, with 6500 square miles (10,391 square kilometers) and around 650,000 inhabitants, about 1.4% of the Spanish population. Despite these figures, it has been traditionally one of the wealthiest and more industrialized regions of Spain. Its strategic geographical position (almost mandatory throughway for people and goods crossing from continental Europe to the Iberian Peninsula), high educational level of the population, and relevant industrial workforce, have been key factors in the economic growth of the region. Navarra was in 2012 the third Spanish region in terms of GDP per capita, after the Basque Country and Madrid, and is traditionally among the three regions with lowest unemployment rates. Navarre is the second Spanish region in research and development expenditure (1.9% of GDP) and in percentage of companies involved in technological innovation. The industrial sector in Navarra is the most relevant one, and represents around 30% of its GDP. The capital city is Pamplona. More than half of the population lives in Pamplona or the surrounding areas.

One of the key emerging economic sectors over the last decade has been renewable energy. Navarre has become one of the leading European regions in this sector [3], and nowadays approximately 65% of the electricity consumed in the region is generated by renewable sources, specially wind power. In December 2009 the region's installed capacity in renewables was already 1,507 MW, of which 980 MW came from wind power. Today this sector is one of the most important ones in terms of recruitment of young engineers in the region. More than 100 companies involving more than 5,000 jobs directly related to this sector have been created, which accounts for more than 5% of the GDP of Navarre. In fact, at present some of the most relevant Spanish companies in the area of renewable energies have headquarters in Navarre and are leading the wind farm development sector (AccionaEnergía, GamesaEnergía, Eólica Navarra and Iberdrola) and also the wind turbine and components manufacturing sector (AccionaWindpower, Alstom Power, GamesaEólica, Ingeteam, and M. Torres) [4].

Another important strength of Navarre is higher education. Nowadays, about 5% of the population of the region is enrolled in higher education institutions. Navarre has three universities and a student population of about 27,000 students. Among the most relevant fields of study it can be mentioned engineering, medicine, architecture, economics, and law, to name a few.

B. The Public University of Navarre (UPNa)

Among these universities, the only public institution not focused to distance education is the Public University of Navarre. It is a relatively young institution that was established in 1987 on the initiative of the Parliament of Navarre. The institution has two campuses: Pamplona and Tudela (the second town in Navarre in terms of population). The campus in Pamplona covers over 250,000 square meters.

The Public University of Navarre has around 9,000 students and more than 900 professors that give lessons in some of its 19 four-year degrees and 25 master programs, most of them taught in the campus of Pamplona. Concerning research activities, the University has about 1,000 researchers inscribed in more than 100 research teams. Around one third of the researchers belong to engineering and technology areas. There are two R&D institutes in the fields of Agrobiotechonology and in ICT & Electronics.

C. The School of Industrial and Telecommunications Engineering

The School of Industrial and Telecommunications Engineering is its largest center of the Public University of Navarre and accounts for around 50% of the university in terms of students, degrees, professors, researchers and R&D contracts with public and private funding. Currently, the School offers six four-year degrees in Industrial, Mechanical, Electrical, Telecommunications, and Computer Engineering, as well as several master programs in Renewable Energies, Materials, Applied Engineering, Manufacturing, Communications, Biomedicine and Computer Engineering. These degrees replace the former 5-year and 3-year engineering degrees traditionally offered in Spain, in a transformation process shared by other European institutions and that is described in more detail below.

D. The European Higher Education Area (EHEA) and the redefinition of the curricula

The emerging European Higher Education Area (EHEA) has modified significantly the structure of the academic programs offered by the School of Engineering as well as in all the Spanish higher education institutions. A major change that the EHEA implies is the establishment of a generic two-level degree system (Bachelor and Master degrees) and the introduction of the European Credit Transfer System (ECTS) [5] as a measure of the workload of the student, including all the course activities (contact hours, labs, exams, self-study, etc.). In Spain an ECTS corresponds to 25–30 hours of student work. However, the change pursued by the EHEA does not only involve the structure of the academic programs. It implies a more profound reform with strong implications in the conception of the higher education. The new EHEA involves a redefinition of the way engineering is taught, which becomes more oriented to practical, cooperative and project-based learning [6–9]. This redefinition, among other implications, requires the active involvement of the companies that will eventually recruit students in the definition of the academic programs and in the acquisition of transversal competences directly linked with real-world situations that the students must face once they are part of the workforce of such companies.

2.4 The UPNa Chair for Renewable Energies Initiative

This section describes the UPNa Chair for Renewable Energies, one the most successful initiatives of the Public University of Navarra in terms of cooperation between the university academic world and the industry real world. First, the origins of the Chair are outlined and then its structure and key activities are presented. Finally, some figures are given to show the positive impact of its Program for Final Engineering Projects and Master Degree Thesis on the degrees currently offered by the School of Industrial and Telecommunications Engineering, particularly the Industrial Engineering Degree and the Master Degree in Renewable Energies.

A. Origins

With a 5% contribution to the Navarra GDP, the renewable sector is responsible for an important wealth creation and technological development in Navarra. The sector accounts for about 2% of the working population of the region, and this percentage rises dramatically when considering only the engineering jobs. The UPNa Chair for Renewable Energies was funded with the aim of providing a space of cooperation between this important industrial sector and the University. Apart from the UPNa, the Chair is formed by four leading companies (GAMESA, INGETEAM, Acciona Energy and AccionaWindpower) and an international technological center (CENER). The collaboration agreement was signed in 2009, and after four years of activity the Chair has become the most important one of the School of Industrial and Telecommunications Engineering in terms of annual budget, activities and people involved.

B. Structure

The Chair is supervised by the Chair Steering Committee, which is formed by one member of each company and six professors of the University. One of the professors must belong to the School of Agricultural Engineering in order to establish a direct link to the activities related to renewable energies this school also develops. The Steering Committee, which is chaired by the Dean of the School of Industrial and Telecommunications Engineering, approves and supervises the Chair activities and the annual budget, and decides who are responsible for the activities. It can also approve other partners joining the Chair, as well as the entry requirements for these new members.

The Chair is managed by the Head of the Chair, who is a professor directly appointed by the university Rector. The Head is in charge of supervising the activities approved by the Steering Committee, and spends the budget accordingly. A Technical Manager helps the Head of the Chair in the day-to-day supervision of specific projects and in the organization of public activities such as conferences and seminars. The Technical Manager is also a professor of the School appointed by the Rector.

C. Activities

Although the UPNa Chair for Renewable Energies was designed to develop any activity related to the renewable energies, some activities are particularly considered as key for the success of the Chair. These activities are:

- Final Project works and Master Thesis of the Engineering Degrees offered by the Public University of Navarre.
- Joint research projects in the short, medium and long term, with special mention to doctoral thesis carried out in cooperation with industry.
- Conferences and seminars open to professors and students in the fields of the renewable energies.
- Technical training courses given by university professors to workers of the Chair partners.
- Specific internships in the company for undergraduate and master students
- Awards for the best Engineering Degree Final Projects, Master Thesis and doctoral thesis.

Since the Chair was funded four years ago, most of these activities have been developed. The most important one is the Program for Final Engineering Projects and Master Degree Theses, which will be described below. The design and development of joint research projects is another key element of the Chair. Some research projects have started and are still on-going with good partial result. The Chair is still too young for big research projects but hopefully some of the present projects will turn into larger projects in the next few years. Finally, several conferences are held every year, in which professionals talk about particular topics within the renewable energies field, such as wind systems, offshore wind technology, photovoltaic solar plants, electric cars, thermoelectric solar energy systems, legal issues, etc. With more than 150 attendees on average, including students, professors and industry workers, the conferences are one of the most important meetings in the University, and particularly in the School.

D. The Chair Program for Final Engineering Projects and Master Degree Thesis

This Program provides a natural commonplace to identify industrial needs and propose specific projects to offer to final year engineering students, both at a Graduate and Post-Graduate levels. The first step is the call for proposals of new projects to the partners of the Chair. The companies then propose the most interesting topics and the Head of the Chair, with the help of the Technical Manager, turns these topics into specific Final Degree Projects or Master Theses. Two supervisors are defined for each project, one from the company proposing the project and one from the university. The list with the projects is then made available to the students, who can talk to the supervisors in order to decide which project they want to apply for. Once the call is closed, the students get marks according to their academic records and resumes. Finally, the students are selected and the projects start. The projects usually last one academic year, and their development is supervised by the Chair.

With this program, a close interaction is established between work staff in the companies, the students and the engineering school that is mentoring these projects. The experience is demonstrating the benefit of such synergic approach, both enabling students to achieve the desired training and skills to work in a multidisciplinary environment and companies to perform a more efficient recruitment of their future personnel. Latest results show that, even in the actual context of economic crisis, up to 80% of the students participating in the Class are hired by the companies after achieving their degrees.

3. Main results/actual benefits of the approach followed for promoting professional skills

Once the different frameworks have been described, an overview of the type of projects, the methodology and the obtained results will be given. A summary with topics currently under development, both under the Renewable Energy Liaison and under EE Faculty Liaison is depicted in Fig. 3.

The projects developed within the Renewable Energy Chair are determined in close coordination with the companies which from part of the Chair. In the case of Industry/University relations established by the Faculty, each one of the projects are prepared taking into account the specific technical requirements from the involved companies, an integral learning process for the student and the research domain in which the faculty members are specialists. At this point, the state of the art within the scope of the project is studied and the work plan is established, which includes tasks such as planning, design, simulation and measurement procedures. After constant feedback from the student, the company interface and the involved academic staff, the project is developed. The final part would be the development of the final report (which usually leads to the Final Degree or Master

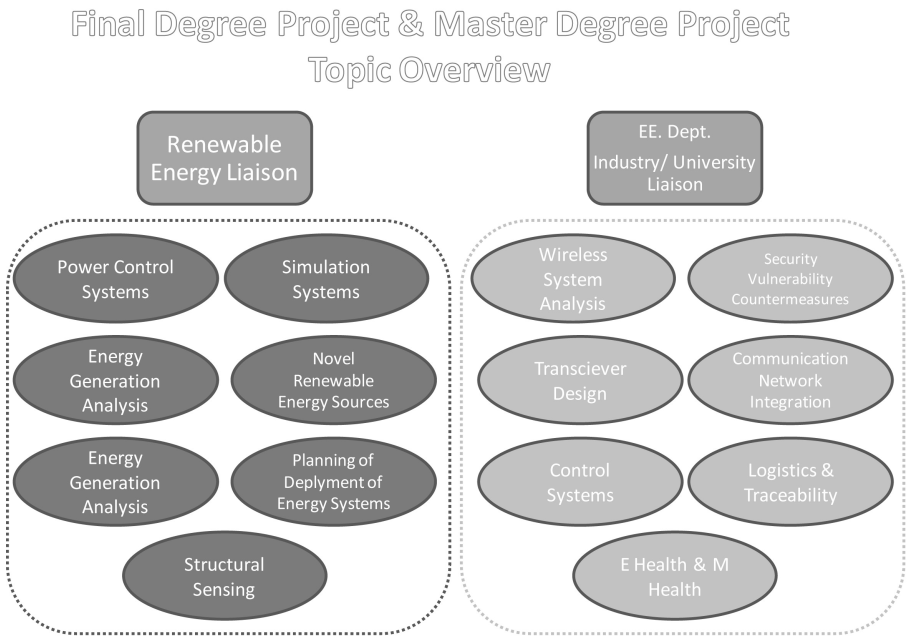

Fig. 3. Overview of Final Degree Project and Master Degree Project topics which are developed by the students.

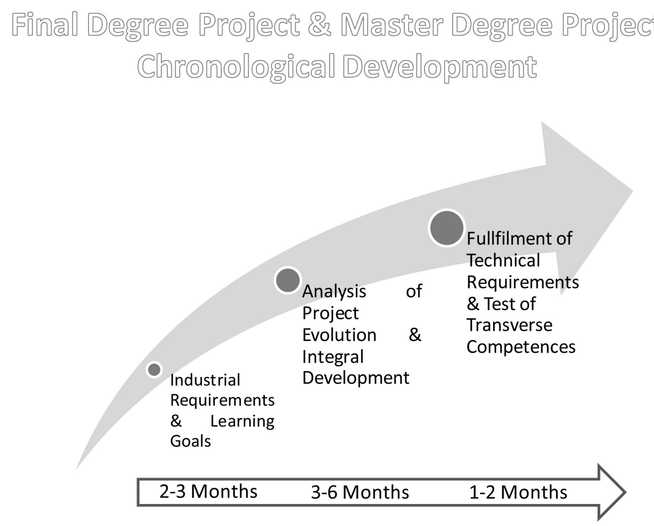

Fig. 4. Overview of the Project Development Phases and typical time spans for each phase.

Degree thesis) and the evaluation, which is implemented by an oral evaluation from an expert committee. An overview of this process is shown in Fig. 4.

In order to obtain assessment in the learning process, direct feedback from students, industry contacts and faculty has been obtained, in terms of descriptive comments of such process. The information obtained is summarized as follows:

In the case of students, the obtained comments are the following:

- The search for industry focused specifications is observed as a very positive element in the development of the project.
- Performing the project within a company framework is perceived as a greater opportunity to engage earlier in professional activities.
- The opportunity of working on the company premises gives a complete overview of what the students expect when they will begin their professional ventures. This holistic point of view includes several aspects of company daily life:

integration with colleagues, technical duties, administrative duties, etc.

- The students feel supported both by the industrial contacts as well as by the faculty members who supervise the projects. This gives a dual perspective on the development and goals to be accomplished, which aids in increasing student confidence.
- One of the most valuable aspects is to have a clear techno-economical view of the project. The topics of the projects to be developed are usually in line with current industrial activities of the companies and hence, budget constraints are analyzed.
- In line with the previous comment, in several cases, the developed project was part of ongoing industrial developments, in which project schedule was a mandatory constraint. This was seen as a relevant element within the learning process.
- The use of corporate applications as well as in house procedures was necessary in all of the proposed projects. This was not seen as an entry barrier; on the contrary the general perception is that of an opportunity to get valuable hands on training.

In the case of Industry contacts, the experience has been described as very positive. Two clear indicators of this is the high degree of job placements of the students after defending their projects and the continued funding the Renewable Energy chair, as well as individually funded projects. In general terms, industrial members state that:

- Students come with a very high motivation and willingness to learn in all aspects within their project development phase.
- Students are flexible in terms of project changes, schedules and other events that can occur within project development.
- The general technical level is perceived as adequate by industry. There are still improvements which have to be made in relation with marketing, sales and organization aspects. This is a relevant statement, which is at this point being actively considered in to prepare undergraduate as well as graduate curricula within the universities under the scope of this work.
- Industry has clearly indicated the need of flexible, adaptable and global oriented individuals in order for them to succeed. This is actively exercised within project development and the overall view is positive for industry and students alike.
- Team work is clearly developed within the development of these projects. This is an overall comment by all of the actors (students, industry and academia) and has been specially indicated as a valuable element by industry.
- Development phases within companies are usually increased, due to the fact that students and faculty actively participate in the project. This leads to an increase in productivity and to new research opportunities for faculty.

In terms of faculty, the feedback gives the following information:

- Productivity is in general considered high from the students which are involved in such projects.
- The responsibility towards the companies is clearly observed by faculty team as an additional element of pressure and also of motivation to excel within the proposed projects.
- The degree of independence in this type of projects is clearly developed within their execution. Students in general make a relevant effort to demonstrate their capability of solving problems, seeking basically guidance and advice, whilst working as part of a team.
- The industry-academia relations are in general tighter after the projects have been completed, which leads to new projects, with students as well as more complex research oriented initiatives with academia.

In relation with the goal of increasing the acquisition of skills by students following the proposed method as compared with previous methodology, a quasi-experimental approach based on personal interviews have been analyzed, both by students as well as by faculty has given as an initial outcome that the students have increased their competences in relation with: autonomous work, integration in workgroups, interpersonal abilities and communication skills.

To summarize, an overview of the obtained assessment results is shown in Fig. 5.

4. Conclusions

In this work, the development of multidisciplinary skills of Undergraduate and Graduate by means of Final Degree Projects and Master Degree Projects has been described. With the aid of specific tools, such as a Renewable Energy Chair or by the ongoing efforts of faculty to maintain Industrial Liaisons, a framework in which students can develop their projects is implemented. The outcome of such initiatives is the development of projects in which close interaction between students, industry contacts and faculty leads to an environment in which a wide range of competences are developed. The overall satisfaction levels are high, in which students perceive useful hands on training, industry has the opportunity of receiving specifically trained future employees and faculty opens new research opportunities. The outcomes of this initiative are

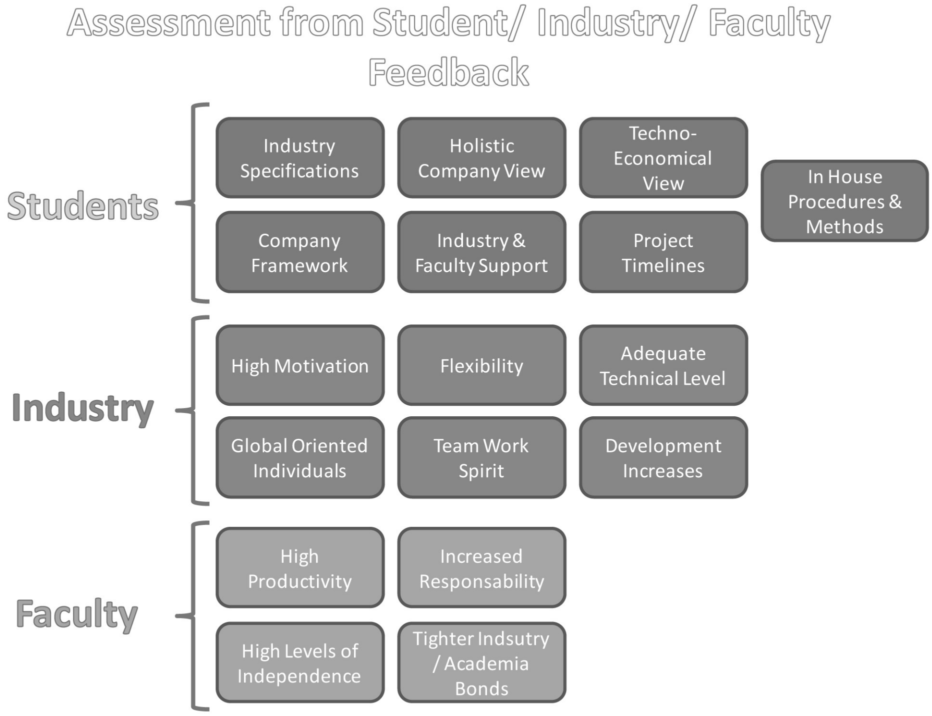

Fig. 5. Overview of the comments obtained within the assessment results from students, industry members and faculty members involved within the learning process.

being analyzed in order to increase student employability, open specific research lines and to enhance future student curricula prepared by the participating universities.

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