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Implementation of Higher Education and Life Long Learning Curricula based on University-Industry Synergic Approach*

FRANCISCO FALCONE[1], ANA VAZQUEZ ALEJOS[2], JAVIER GARCÍA CENOZ[1,3] and ANTONIO LOPEZ-MARTIN[1]
[1] Departamento de Ingeniería Eléctrica, Electrónica y de Comunicación, Universidad Pública de Navarra, Navarra, Spain. E-mail: francisco.falcone@unavarra.es
[2] Departamento de Teoría de la Señal y Comunicaciones, Universidad de Vigo, Vigo, Spain. E-mail: analejos@uvigo.es
[3] Telefónica Móviles, Navarra, Spain. E-mail: javier.garciacenoz@telefonica.es

In this paper, the experience in collaboration and feedback between different agents from University, Private Companies and Public Companies is presented. Several learning scenarios, from undergraduate studies, postgraduate studies, in-house training and external training, have been implemented and all of them have a common preparation basis. Due to the fact that it has been possible to interact and to allow interaction between all of the different agents, a very fluid and consistent feedback has been present in the process. This interaction has led to the identification of key elements in the learning process, of generic as well as specific competences directly demanded by industry, as well as topics of improvement in the methodology followed in Lifelong Learning programs within Industry. Such information is the basis of actions, some of them implemented and others in implementation phase within different specific courses in Engineering curricula.

Keywords: accreditation; engineering education; European Higher Education Area (EHEA); learning skills; quality assurance; EUR-ACE

1. Introduction

From the engineering perspective, students as potential professionals cannot limit their training to a baggage of theoretical knowledge disconnected from the industrial environment, and so the University as main formative institution of technical professionals cannot be relegated to be a mere tool to transfer non-professionally oriented knowledge.

Engineering education constitutes a challenge in the alignment of Learning Outcomes (LOs) and its assessment in the category of professional skills [1–4]. At present, an engineering programme must demonstrate that students attain any additional outcomes articulated by the programme to foster achievement of its educational objectives [1–6].

The major reforms accomplished by the European educational systems in the last decade aimed to consider accreditation programmes in order to assure educational programmes of acceptable academic standard that prepare graduates who are able to assume relevant roles in the worldwide job market [7–10]. The participation of non-academic stakeholders in the process is a guarantee to this effect. Internationally recognized qualifications like the Abet [11] or EUR-ACE [12–14] labels, added to the national accreditations, have become quality assurance tags that additionally aim, in last term, to facilitate job mobility [7–14].

The EUR-ACE Framework has been taken, together with the ABET criteria [7, 11, 13], as the basis of a "Conceptual Framework of Expected/Desired Learning Outcomes in Engineering" developed by the Tuning-AHELO (Assessment of Higher Education Learning Outcomes) project [15, 16], that in turn should be the starting point for the further developments of the very ambitious AHELO initiative.

The EUR-ACE Framework does not intend to substitute national standards, but to provide a common reference framework as the basis for the award of a common European quality label [7–10]. Therefore, the EUR-ACE Standards identify 21 programme LOs for First Cycle degrees (FC) and 23 for Second Cycle Degrees (SC), grouped under six categories, as indicated in Fig. 1: Knowledge and understanding, Engineering analysis, Engineering design, Investigations, Engineering practice, Transferable skills.

The EUR-ACE Framework expresses the learning outcomes to be achieved by FC and SC graduates in the three direct engineering requirements, as defined in Table 1, by the phrase "consistent with their level of knowledge and understanding", and this level is described using the concept of the forefront of the particular branch of engineering. For instance, in the requirement "Knowledge and Understanding" the relevant phrase is for FC graduates, "coherent knowledge of their branch of

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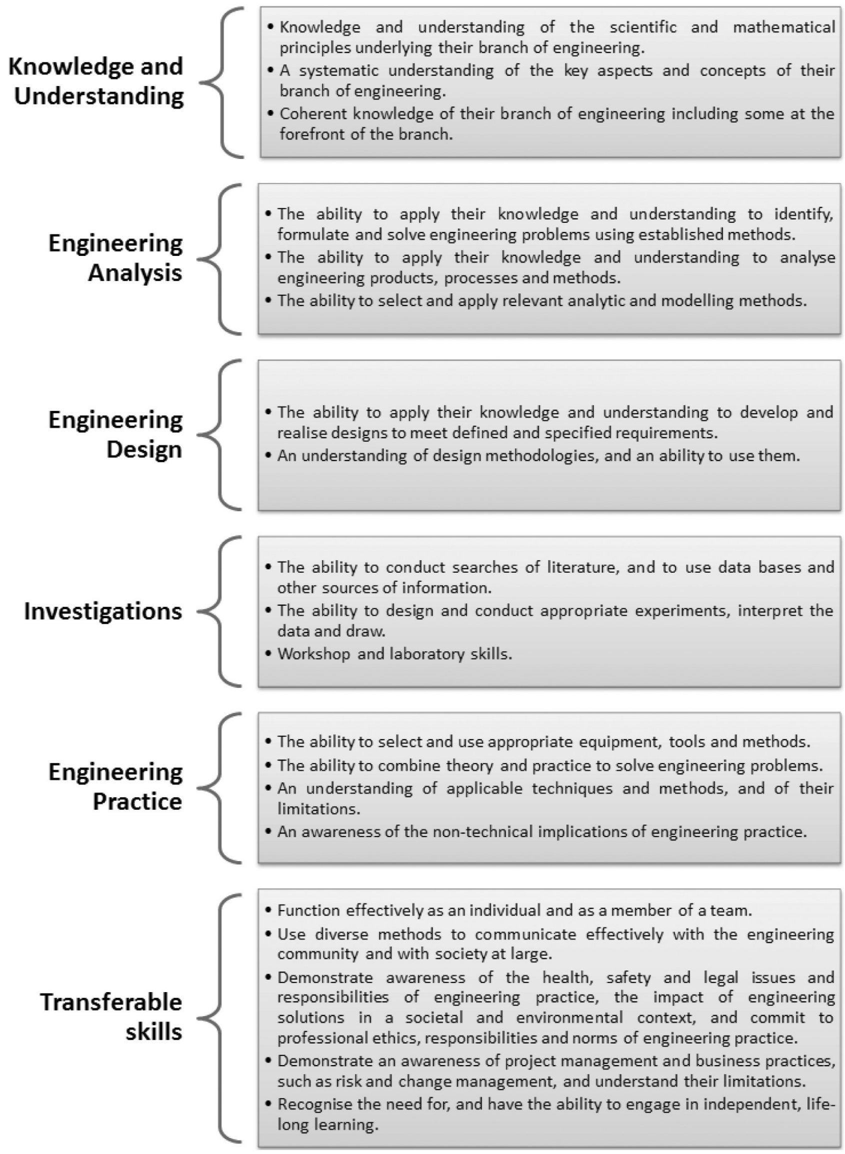


Fig. 1. categories of LOs for EUR-ACE accreditation standard.

engineering including some at the forefront of the branch'' and for SC graduates ''a critical awareness of the forefront of their branch'' [7, 12, 13].

The EUR-ACE Standards defines procedures for the assessment of an educational programme that seeks accreditation. The assessment procedure lists a set of must to have in place:

- Programme educational objectives consistent with the mission of the Higher Education Institution (HEI) and the needs of all interested parties (such as students, industry, engineering associations, etc.) and programme outcomes consistent with the programme educational objectives and the programme outcomes for accreditation.
- A curriculum and related processes which ensure achievement of the programme outcomes.
- Academic and support staff, facilities, financial resources, and so on, adequate to accomplish the programme outcomes.
- Appropriate forms of assessment which attest the achievement of the programme outcomes.
- A management system able to ensure the systematic achievement of the programme outcomes and the continual improvement of the programme

Contrasting former trends that prescribed only inputs, without well-defined outcomes, in term of subject areas and teaching loads, the EUR-ACE Framework approach defines and requires LOs in order to determine what must be learned rather than the form to teach those [7, 8]. Then, the identification of the forefront of the branch is the responsibility of the members of the accrediting panel who are experts in that particular branch of engineering,

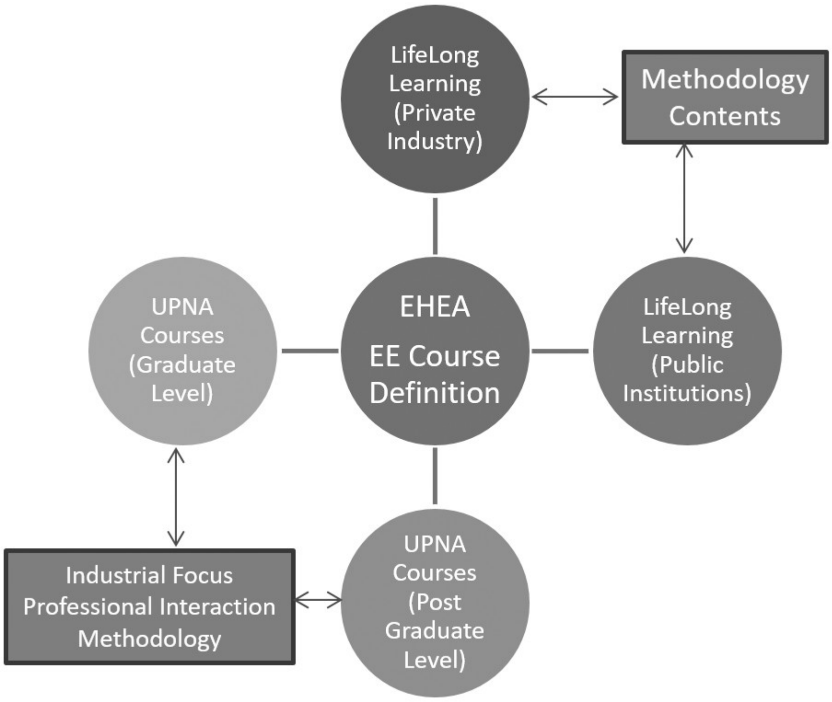


Fig. 2. Different levels of inter-relation between academia/industry educational demands and resources in order to accomplish an integral approach for future curricular implementation.

while the body responsible for the final accreditation verdict will review and assess the rationale for their decision [7–10].

This implies that, for instance, for the assessment of ''Resources and Partnerships'' it is enough to provide a self-assessment report by the HEI to evidence of local/regional/national/international industrial partnerships and cooperation agreements to achieve that criterion as positively assessed. We note then that lacks exist even in well-recognised accreditation processes and, in last term, it is responsible of the involved HEIs to diagnose the reality.

In this line, we present in this work the different initiatives developed by internships of HEIs and industrial/professional partners to enhance the engineering curricula in general but particularly in the development of professional skills of future engineers.

In this research work we describe collaboration and feedback between different agents from University, Private Companies and Public Companies for several learning scenarios, from undergraduate studies, postgraduate studies, in-house training and external training, so that it has been possible to interact and to allow a solid interaction as well as a very fluid and consistent feedback leading to the identification of key elements in the learning process, of generic as well as specific competences directly demanded by industry, as well as topics of improvement in the methodology followed in Lifelong Learning programs within Industry. A schematic representation for the process is shown in Fig. 2.

The paper has been organised in four sections. Section 2 describes the context in which this work is carried out. Section 3 describes the interaction framework between academia and industry, with the results for the specific courses that have been analyzed. Finally, conclusions in Section 4 close this paper.

2. EHEA Framework: The particular case of the Universidad Publica de Navarra (UPNA) and Engineering Curricula

In this section, the framework in which this work is carried out is described. The starting point will be the European Higher Education Area, which will be adapted to the regulatory environment in Spain and the particular implementation within the Universidad Pública de Navarra (Public University of Navarre, UPNA). This will settle the methodological approach for designing future engineering curricula and the identification of particular competences strongly linked with the industrial world, which will be described in practical terms in section 3.

2.1 European Higher Education Area (EHEA)

A profound transformation of the higher education system is taking place in Europe in the last decade, known informally as Bologna process and aimed to creating a common European Higher Education Area (EHEA). Among the main objectives of this initiative are: increasing the mobility of students and teachers and creating a system of qualifications [17–24]. Some major changes of the EHEA are the establishment of a generic two-level degree system (Bachelor and Master degrees) and the introduction of the European Credit Transfer System (ECTS) [25–27] as a measurement of the workload 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. The new EHEA involves a redefinition of the way engineering is taught, which becomes more oriented to practical, cooperative and project-based learning [28–41]. However, the convergence to the EHEA-adapted engineering programs is becoming slow and complicated in Spain and information about the transformation process in high schools and in society generally is very limited and sometimes confusing. A remarkable difference of the new degrees in Spain adapted to the EHEA is that undergraduate degrees have 8 semesters, while in most European countries they have 6 semesters. Concerning the Master degrees, they usually have in Spain between 2 and 4 semesters, while most European countries have 4-semester Master degrees. This difference complicates exchange programs between Spanish and other European universities.

2.2 Institutional context

The UPNA is a public institution mostly funded by the government of the region (Navarre). It was founded in 1987 and currently has around 9,000 students and more than 900 faculty, offering 19 four-year undergraduate programs and 25 Master programs. The region has a population of approximately 650,000 inhabitants and is one of the Spanish regions with the highest GDP per person. It has a relevant industrial activity in various fields like automobile manufacturing and renewable energy, and engineers are historically highly demanded and with low 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 School of Industrial and Telecommunications Engineering (ETSIIT) of the UPNA is the largest one and represents about 50% of the total University in terms of students, faculty, research and development activities. It currently offers six four-year degrees in Industrial, Mechanical, Electrical, Telecommunications, and Computer Engineering, as well as various Master programs on Renewable Energies, Materials, Applied Engineering, Manufacturing, Communications, Biomedicine and Computer Engineering. The old 3-year and 5-year Engineering degrees previous to the EHEA reform will coexist until the academic year 2013/2014 to allow students already enrolled in these degrees to complete them.

2.3 Implantation of the EHEA at the UPNA and the school of industrial and telecommunications engineering

The UPNA started the EHEA adaption in 1998 with activities such as the TUNING (Tuning Educational Structures in Europe) project. In 2008 the main regulations for the design and implementation of the new undergraduate programs adapted to the EHEA where issued by the UPNA, establishing a 3-level hierarchical structure of committees (EHEA committee, Engineering committee and Degree committee). The latter one, supervised by the others, was in charge of designing the undergraduate programs. There was one Degree committee per degree, and it was composed by the Dean of the School, two Deputy Deans, 5 professors (including Department Heads), 2 external professionals (including the President of the Professional Engineering Association in the region related to the degree), 2 former students and 2 current students. The composition reflects the aim of the University to adapt the degree to the needs of the industry. Besides, several meetings and interviews with local companies and employers were carried out during the degree definition process to gain feedback about how the new degrees could better fit the demands of the industry.

2.4 The degree of Telecommunications

The basic structure of the new EHEA-adapted 4-year Telecommunications Engineering degree at the UPNA is shown in Fig. 3. Each semester has 5 courses, corresponding to 30 ECTS. The first year is devoted to basic courses covering topics such as Algebra, Calculus, Statistics, Physics, Electronics, Computer Science, etc. Also an introductory course on Telecommunications Engineering is planned in the first semester to provide students with a general overview of the degree and the profession. During semesters 2 to 5, courses cover the basic knowledge about Information and Communication Technologies (ICT) an undergraduate must have. These courses cover topics from different areas, in order to provide a multidisciplinary approach that will allow a smoother adaption of the students to the requirements of the Spanish job market. In the 6th semester students choose one out of 4 minors (Communication Systems, Telematics, Audiovisual and Multimedia Systems, or Electronics Systems) that corresponds to 6 courses each distributed

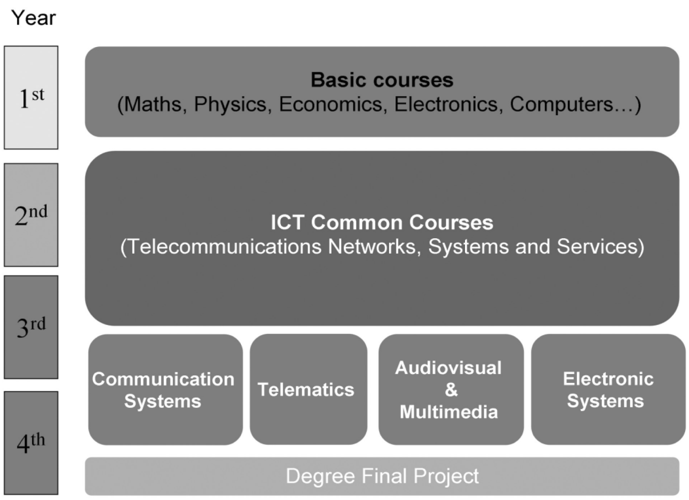


Fig. 3. Structure of the 4-year Telecommunications Engineering degree at the UPNA.

through the 6th and 7th semester. The last semester is devoted to the realization of a final project, to a training stage in a company and/or to elective courses.

3. Industry-academia interaction

In order to analyze the benefits of academia-industry interaction in the development of on-going curricula as well as to future programs, a set of courses were identified for such purpose. These courses were selected according to their proximity to actual needs that were being demanded from several non-academic institutions, such as Telefónica (telecommunications operator), Sección de Telecomunicaciones, Junta de Andalucía (public regional institution) and Sección de Educación, Government of Navarra (public regional institution). The preparation of the courses, the results obtained in their development and the continuous feedback provided from academia as well as industry/public administrations have been the basis for establishing the relation between the different topics and searching for the possible synergies in the educational development in both cases.

The topic of University/Industry has been of interest for the Engineering Education community, which has focused on topics such as the benefit of industrial sponsorship and the integration of students to industry [42–45], the importance of interaction in the definition of competences [46–47] or the proper evaluation of industry needs from emerging engineers [48–50]. Not only is this interaction relevant in the preparation of future engineers, but also in the adoption and development of Life Long Learning, which has proven to be a key instrument in individual fulfillment as well as in increased organizational performance [51–54]. This is an increased motivation in searching for Academia/Industry synergies in order to enhance the educational process in both cases. It is also worth noting that the authors have been involved in the preparation of new EHEA degree curricula for engineering, as well as in a series of industry oriented educational activities. By individual observation from each one of the perspectives, it was soon stated that synergies from both the University and the Industry would be beneficial in order to enhance the educational process. Moreover, both of these processes could provide valuable feedback, in order to adapt contents and methodologies for the engineering curricula to be industry oriented and Life Long Learning programs could better fulfill the expectations of seasoned professionals.

In this section we will describe the courses that have been considered in relation with the development of competences in wireless communications, as well as the demands foreseen in each of the institutions and the corresponding feedback towards the initial university courses. The time span that has been considered goes from 2005 to 2011 and the feedback for new EHEA based courses is being put in practice in 2012. The description follows the implementation of the feedback process, i.e. in a dynamical way, which is due to the fact that interaction between Academia/Industry has been simultaneous and progressive. In the course description, there are elements inherent to this feedback, such as a project-based final report presentation or a methodological use of scientific texts or standards.

3.1 Course description in wireless communication systems at UPNA

Wireless communications has become one of the

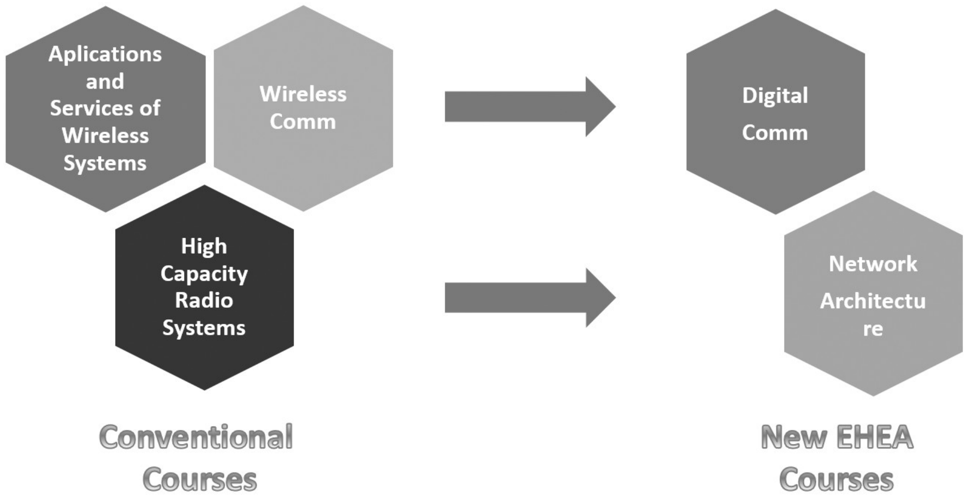


Fig. 4. Courses under analysis in Telecom Engineer/Computer Engineering degrees offered at the Universidad Pública de Navarra.

main economic drivers in modern economy and one of the most exciting professional outcomes for engineers in general and especially for Telecommunication Engineers and Computer Engineers. The potentially transversal application of wireless technologies to a broad range of industrial, administrative and domestic scenarios and the possibility to have direct feedback from industrial/administrative bodies defined this topic as adequate for the Industrial/Academic feedback. In our analysis, we focus on several courses of different levels related with wireless systems. A schematic overview of these courses is shown in Fig. 4 (including new EHEA courses) and its interaction with different engineering degrees is shown in Fig. 5 which will now be described.

Applications and Services of Wireless Systems: This is a transverse course that has been offered to engineering students from all specialties at UPNA. The main goal of the course is to give an overview of

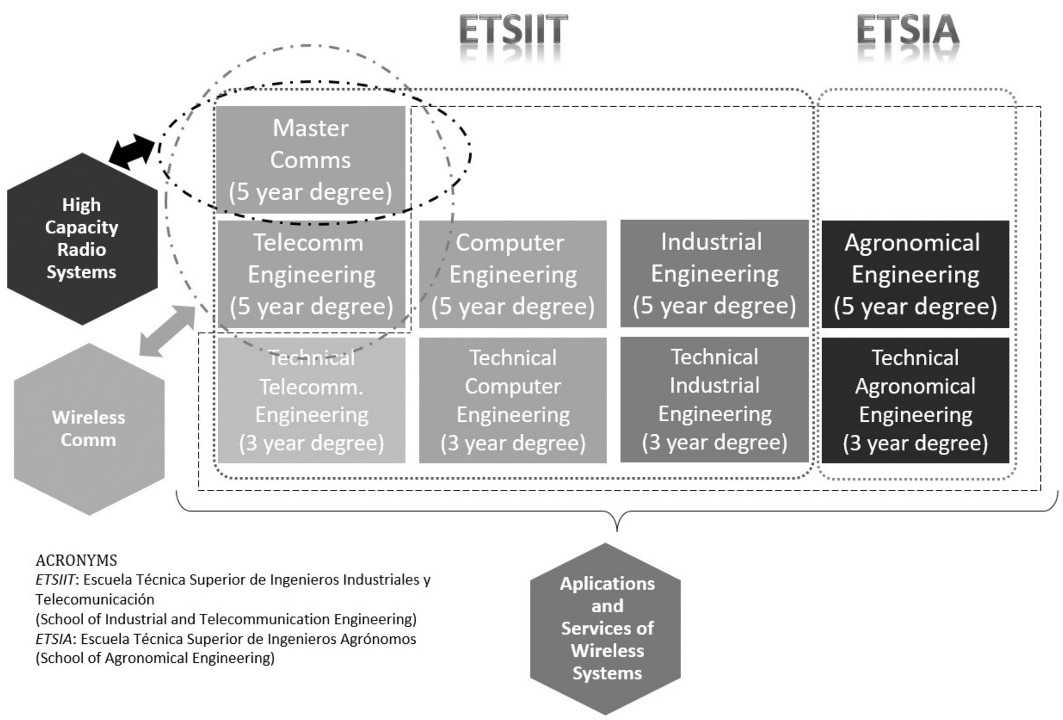


Fig. 5. Courses under analysis from conventional degree programs and their relation with different engineering degrees, as well as the related engineering school.

the fundamentals of operation of wireless systems as well as insight in services that wireless systems can offer, in order to provide added value to a wide variety of sectors. The evaluation methodology is based on continuous evaluation, by completing weekly tasks, as well as by the preparation and presentation of a final project. Classroom activity is complemented with a specific website implemented in Sakai, including elements such as material repository, blogs, chats, wiki and message/mail notifications. Moreover, online management of weekly tasks is also performed within the website, enhancing the evaluation process. Students come from any engineering course at UPNA, except those who are enrolled in Telecommunications Engineering (5 year degree).

Wireless Communications: This course is offered to final year students enrolled in the 5-year Telecommunications Engineering degree, as well as to students who are enrolled in M.Sc. in Communications Engineering at UPNA. The goal of the course is to give an overview of the operation of wireless systems, with special emphasis on physical implementation, radio propagation phenomena and initial system-level design. The evaluation methodology is based on final written exam, as well as on the preparation and presentation of a final project. Web resources are commonplace for this course, as in all of the courses offered at UPNA.

High Capacity Radio Systems: This course is offered within the M.Sc. in Communications Engineering at UPNA. Evaluation is based on continuous evaluation by performing weekly/bi-weekly tasks, group exercises focused on advanced radio propagation/radioplanning considerations and writing and presenting a final report. The final report in this course is a case study that has to follow technical as well as economical parameters in its elaboration. Students have a strong knowledge of wireless phenomena in physical layer and the course aims in specializing in radio channel estimation techniques applied to radioplanning (empirical and deterministic based techniques), system level design and overall economic impact in deployment of wireless services and networks.

The main characteristics of the courses, their target audience and the potential industry/academia feedback are shown in Table 1.

Along with the courses previously described, two more courses have been included in Fig. 2, which are part of the new EHEA courses offered at UPNA. Digital Communications is a course part of the 4-year Degree in Telecommunications Engineering described in Section 2.4, located in the second academic year. Network Architecture is a course part of a Degree in Computer Engineering, offered in the third year, also in a 4 year program. In both cases, these courses offer the students partial contents related with wireless communications. In the first case, related with physical layer aspects and

Table 1

Course	**Application and Services of Wireless Systems**	**Wireless Communications**	**High Capacity Radio Systems**
Degree Program	• Transversal/Engineering Degrees	• Telecommunications Engineering • Degree/Master in Communications	• Master in Communications
Evaluation Methodology	• Weekly Tasks (Continuous Evaluation) • Final Project (Report+Presentation)	• Written Exam (Theory+Practical Exercises) • Final Project (Report+Presentation)	• Weekly Tasks (Continuous Evaluation) • Final Project (Report+Presentation)
Impact of Industry/ Academia Feedback	• Implementation of Real Systems • Additional Tools for improving-optimizing processes	• Techno-Economical analysis of systems as well as devices • Knowledge of current industrial practices	• Integral vision of Wireless solution and market • Current equipment specifications and industrial demands
Initial Knowledge Base	• Basic knowledge, fundamentally based on user experience	• Strong Theoretical concepts at the physical layer (propagation and signal processing) • Notions on device and component level • Basic System level	• Advanced Theoretical base • Medium level at device and component level • Medium System level • Basic Business model notions
Additional Comments	• Students come from a wide variety of engineering specialties and different study levels (mid-career and final career stages). Threshold level has a large hysteresis	• Telecommunication Engineering Students (5 year degree or Masters students, usually from a BSc in Telecommunication Engineering)	• Master Students, usually coming from Telecommunication Engineering Degree (in some cases, Industrial Engineers with additional supplementary courses)

signal processing of wireless communications, whereas in the second case it is devoted to describing the role of wireless networks in the overall topology of a network. These two courses will be considered for the adoption of the Academia/Industry interaction outcomes and will be described in the final part of this section.

3.2 Course description in industry/public organizations

Once the courses under analysis within the academic framework at UPNA have been described, we will now focus on the training demands within the field of wireless communications in Industry as well as in public government agencies. In both cases, the interaction is possible due to the fact that one of the authors participated as internal instructor within Telefónica Group, which is the largest global telecommunications operator in Spain and one of the relevant operators worldwide. Training within Telefónica is developed with the aid of external instructors (usually from equipment and service vendors) as well as from a base of internal instructors. Internal instructors are full time employees, with professional experience in the field of training and that have successfully passed external technical evaluation examination as well as external psycho-technical evaluation. Once the internal instructors have passed the corresponding evaluations, courses are given while still maintaining the original professional activity in the initial post. In this paper, the professional profile was in a post related with radio network planning and optimization of mobile wireless systems, from second generation GSM systems to 3.75G data transmission networks given by UMTS based High Speed Packet Access systems. The courses that were prepared were devoted to Radio Planning as well as to functionalities in close relation with wireless system optimization. The set of courses that has been prepared is shown in Fig. 4. Not only courses were given to employees of Telefónica, but due to the experience as internal instructor and within the relation the operator has established with other private companies as well as with administrations, a series of courses were prepared within the scope of wireless communication systems, as also shown in Fig. 6. The time span for the analysis of the results is from year 2005 to 2011. A brief description of each of the courses will now be given.

UMTS Planning and Optimization: this course deals with the radioelectric planning focused to the deployment and optimization of third generation wireless UMTS systems. The students are employees of Telefónica involved in Mobile network implantation, optimization and maintenance. Approximately 80% of the students are Telecommunication Engineers, 10% have a Physics/Mathematics degree and the rest of the students, usually related with maintenance operations have technical

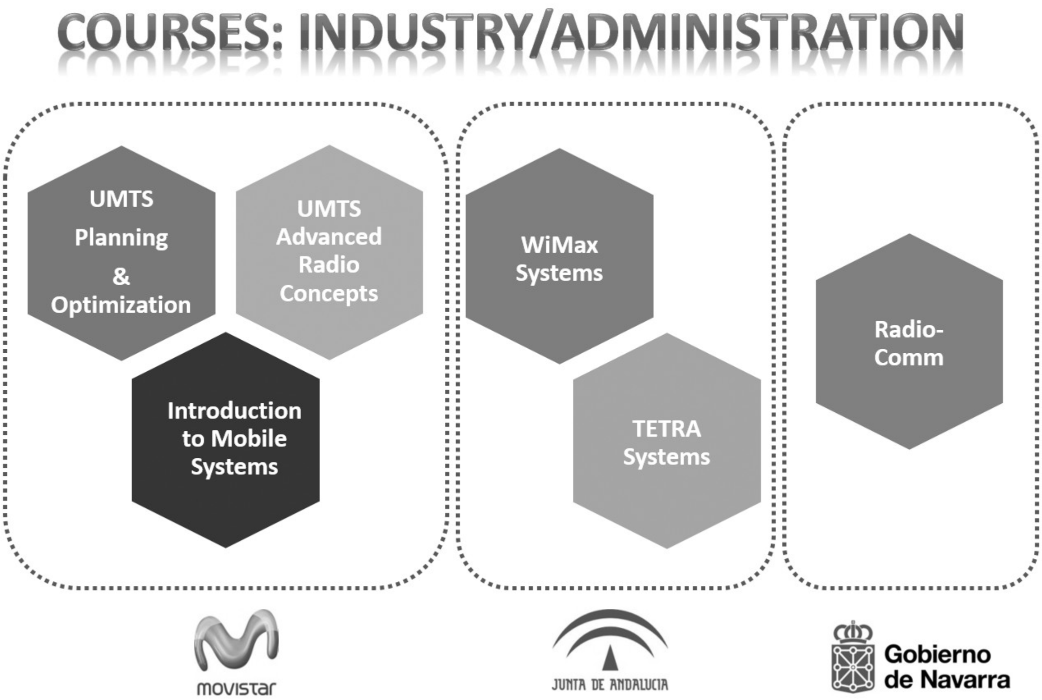


Fig. 6. Schematic representation of training developed within the Industry/Public Administration framework. In the case of Movistar (Telefónica), the courses were given as internal instructor to work colleagues, whereas in the case of public administrations it was given as external instructor.

training in electromechanical systems. The course was given on-site in the training center of Telefónica in Madrid (currently in Distrito C, in a global company center in the outskirts of Madrid). The course is intensive in nature, due to the time constraints of the students, which have to leave their posts within the geographical area of Spain, with a time span of 12 hours. The methodology adopted is 8 hours devoted to class room presentations and group tasks and 4 hours with individual computer training. The class is equipped with 1 computer for each student, due to the fact that an in-house radioplanning tool is described and a case study of coverage/capacity calculations is performed. Although most of the students have been practicing engineers with a strong background in mobile communication systems as well as with radio propagation phenomena, some of the class groups required more emphasis on fundamental aspects, due to their specific job functions, which did not deal on a daily basis with wireless engineering tasks.

UMTS Advanced Radio Concepts: this course was designed as complementary training after receiving the previous radioplanning course. The feedback from students as well as the ever-changing requirements imposed by equipment manufacturers as well by 3GPP standards was the main motivation for creating this course, mainly focused on in-depth analysis of radio propagation phenomena, device description and physical layer techniques, such as Multiple Input Multiple Output wireless channel models and Orthogonal Frequency Division Multiple access techniques. This course is also intensive in nature, with a time span of 6 hours, given in 1 day in the training center of Telefónica in Madrid. In this case, all of the students are Telecommunication Engineers, with background in wireless communications.

Introduction to Mobile Systems: in order to meet strategic demands of Telefónica, in 2008 a new set of technically based courses was designed and offered to a wide base of employees. The main goal of the course is to give the necessary background to the students in order to understand the mobile services offered by Telefónica, as well as the limitations inherent to wireless communication systems. The educational background was diverse, with approximately 40% of the students holding Telecommunication Engineering or Computer Engineering degrees, 40% of the students with Physics or Mathematics degrees and the rest of the students with Economics/Administrative/Marketing profiles. In this case, their job functions were transverse, with employees working on Core Network, Residential Clients, Transmission Media, Corporate Service or Mobile system maintenance, just to name a few. The course is structured also intensively, with a time span of 18 hours, divided in 3 days.

In the case of Public Administrations, training was designed and given to Telecommunication Service of the Government of Andalucía, as well as to Education Council of the Government of Navarra. In both cases, they are regional public institutions. The courses that have been developed are the following:

WiMax Systems: the adoption of broadband wireless access technology can be performed with the aid of WiMax systems, based on IEEE 802.16 standards. The goal of this course, within a cooperative relation with Telefónica in the region of Andalucía was to give a complete overview of the WiMax system. The students in this case are public workers within the Junta de Andalucía, mainly devoted to Information Systems, Telecommunication Infrastructure and Civil Protection/Security areas. The course was structured in 2 days, with a total time span of 12 hours and once again intensive due to time constraints of the students. Approximately 40% of the students were Telecommunication Engineers, 40% of the students were Computer Engineers and the rest of the students were divided between Industrial Engineers.

TETRA Systems: given the previous relation with personnel from the Junta de Andalucía, a specific need in relation with trunked digital systems (which in Europe are mainly implemented under TETRA standard) lead to the implementation of a TETRA course. The goal of the course is to give an overview of TETRA systems, from physical layer all the way to application layer and services. The course is designed to be intensive, given in 3 consecutive days, with a total time span of 18 hours. The student base is the same as in the previous course of WiMax Systems.

Radiocommunications: this course was prepared ad-hoc for the instructors of technical programs in vocational training, with the specific need to train the students (which are vocational training professors) in order to prepare a new educational itinerary for Wireless Technicians. This course is intensive due to the fact that the students were required to provide feedback and needs in order to implement their respective course material, different courses and design of new specific training laboratories. In this case, the course was divided in 10 weekly sessions of 4 hours/week, with a total of 40 hours. The methodology adopted in this course was class training, as well as hands-on training with radiofrequency instrumentation as well as with freeware radioplanning software. The students, all of them professors of public vocational training centers managed by the Government of Navarra had a diversified background, with 50% of them with

Table 2

Course	**UMTS Planning and Optimization**	**UMTS Advanced Radio Concepts**	**Introduction to Mobile Systems**
Student Job Function	• Radio Network Planners/ Optimizers • System Level Architects • Operation Staff • Maintenance Staff	• Radio Network Planners/ Optimizers	• Pre-Sales Engineers • Marketing/Sales technical staff • Core Network Engineers and Designers • System Level Maintenance
Course Methodology	• Intensive (2 days/12 hours) • Use of individual PC for simulation case study	• Intensive (1 day/6 hours)	• Intensive (3 days/18 hours)
Impact of Academia/ Industry Feedback	• Inclusion of basic theoretical notions (especially in radio propagation) • Use of engineering articles/ standards as reference base	• Inclusion of basic theoretical notions (time/frequency channel analysis, space/time antenna systems) • Use of engineering articles/ standards as reference base • Introduction to full wave electromagnetic simulation tools	• Inclusion of basic theoretical notions (digital communication concepts, radio propagation constraints) • Review of educational resources (references, standards)
Initial Knowledge Base	• Knowledge of Mobile Communication Systems (2G/ 3G) • Knowledge of deployment/ maintenance procedures • Notions of Radio propagation Phenomena	• Deep knowledge of mobile network planning and optimization • Knowledge of radio propagation concepts (path loss analysis) • Knowledge of RF subsystem elements (cables, antennas, connecting devices) • Initial knowledge of simulation techniques and tools.	• Initial knowledge of mobile communication systems (names, type of system) • Knowledge of applications and services offered by the operator. • Initial knowledge of physical operation of wireless systems.
Additional Comments	• Medium/High Technical level, mainly focused on mobile network operation • Focused on radioplanning case study	• High Technical level, strongly focused on radio network optimization • Focused on device characterization and impact on system	• Initial to moderate technical level • Diversity in the job requirements, with an explicitly stated need to gain insight in the basic concepts
Course	**WiMax Systems**	**TETRA Systems**	**Radiocommunications**
Student Job Function	• Information System Technician • Infrastructure Development/ Maintenance Personnel • Security/Emergency Personnel	• Information System Technician • Infrastructure Development/ Maintenance Personnel • Security/Emergency Personnel	• Vocational Education Professor
Course Methodology	• Intensive (2 day/12 hours)	• Intensive (3 day/18 hours)	• Intensive (10 days/40 hours)
Impact of Academia/ Industry Feedback	• Inclusion of basic theoretical notions (digital communication concepts, radiopropagation constraints) • Review of educational resources (references, standards)	• Inclusion of basic theoretical notions (digital communication concepts, radiopropagation constraints) • Review of educational resources (references, standards)	• Inclusion of basic theoretical notions (digital communication concepts, radiopropagation constraints) • Review of educational resources (references, standards) • Application of Higher Education methodological approaches (web platform, lab structure)
Initial Knowledge Base	• Knowledge of Mobile Communication Systems • Knowledge of maintenance procedures	• Knowledge of Mobile Communication Systems • Knowledge of maintenance procedures	• Knowledge of Communication Systems • Knowledge of installation and measurement procedures of RF systems • Knowledge of basic time/ frequency measurement techniques • Knowledge of electric and basic electronic circuit design
Additional Comments	• Focused on understanding integration with actual systems under operation and future benefits in the overall network architecture.	• Focused on gaining insight in order to control tender processes and maintenance issues	• Focused on the educational needs for the future courses to be developed by the professors

Physics degrees (in different areas), 10% Mathematics degrees, 25% Telecommunication Engineering degrees and15% Computer Engineering degrees. The background level of the students was quite different, as well as the age span (from early 30s to late 50s), which was clearly a new factor to take into account in the implementation of the course and the overall learning process.

The main characteristics of the courses previously described are summarized in Table 2.

3.3 Academia/industry feedback and related actions

Once that both educational experiences have been described, the interaction between academia and industry public organizations is analyzed. In the first place, we will present assessment results based on individual anonymous questionnaires done by the students of each one of the university courses, which can be seen in Fig. 7.

As it can be seen, the evaluation of the educational process in all of its stages is perceived as adequate by the students. More specific results have been obtained by means of free text comments within the survey, as well as by indications of the students, which have been the following:

- Students find it useful to have knowledge of real applications and those specific demands in industry. Moreover, those demands appearing in the specific areas of their future job placements.
- The presentation of the final report is very well considered by students. They clearly indicate that it allows them to exercise competences such as clarity in the exposition, focus on the goal of the presentation and communication skills.
- The need to be concise and to clearly identify the main elements of the final report is also evaluated by students positively. As indicated by several students, it is the first time they have to elaborate a structured report with a defined extension limitation (maximum 5 to 8 pages, depending on the course) and with the need to correctly reference the information sources.
- The analysis of real case studies as well as group activities in the classroom, in which a realistic problem is tackled by the students, is positively evaluated. This comment is closely related with the use of real specifications and real equipment in the market, which is seen as positive towards their career development.
- The explanation, search and use of reputable references, in technical and scientific literature as well as in standards, is also evaluated by students as useful for their practical knowledge towards the labor market.

In the case of the courses given in industry/public administrations, assessment from the students was also obtained by means of anonymous surveys, as well as by direct feedback from them. Due to the type of courses, which are very intensive, and the professional background of the students, a great

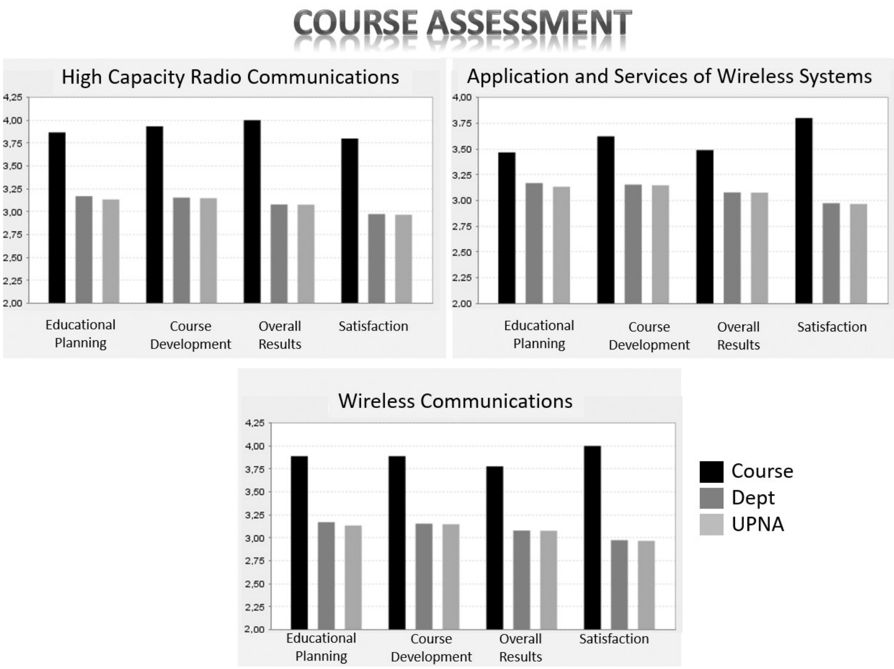
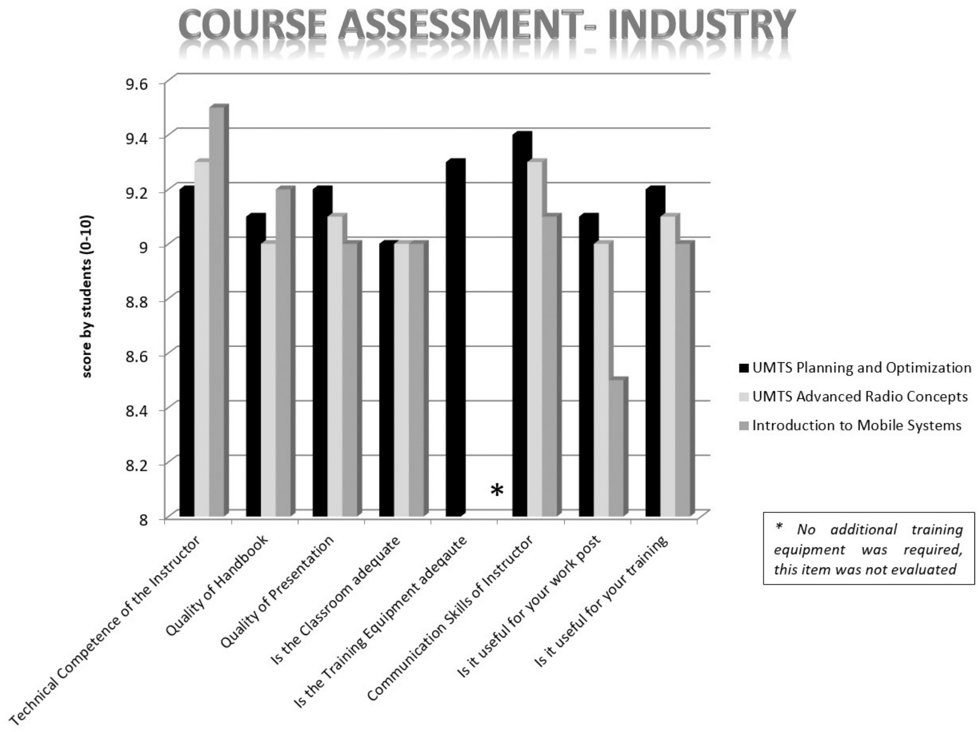


Fig. 7. Results obtained from student anonymous surveys performed for each one of the courses previously described, in an evaluation scale from 0 to 4. The results are compared with the average levels of the courses given by the reference Department (in this case the Electrical and Electronic Engineering Dept. at UPNA) and all of the courses given in the university.

deal of comments and opinions were interchanged within the development of the courses. This is clearly a difference from the interaction with university students, which are not prone to spontaneous comments and usually give their opinion in a one-time basis to the professors when the surveys are filled out. This type of interaction has been very useful in the analysis and definition of the courses and hence the professors have motivated the university students to also approach feedback in this



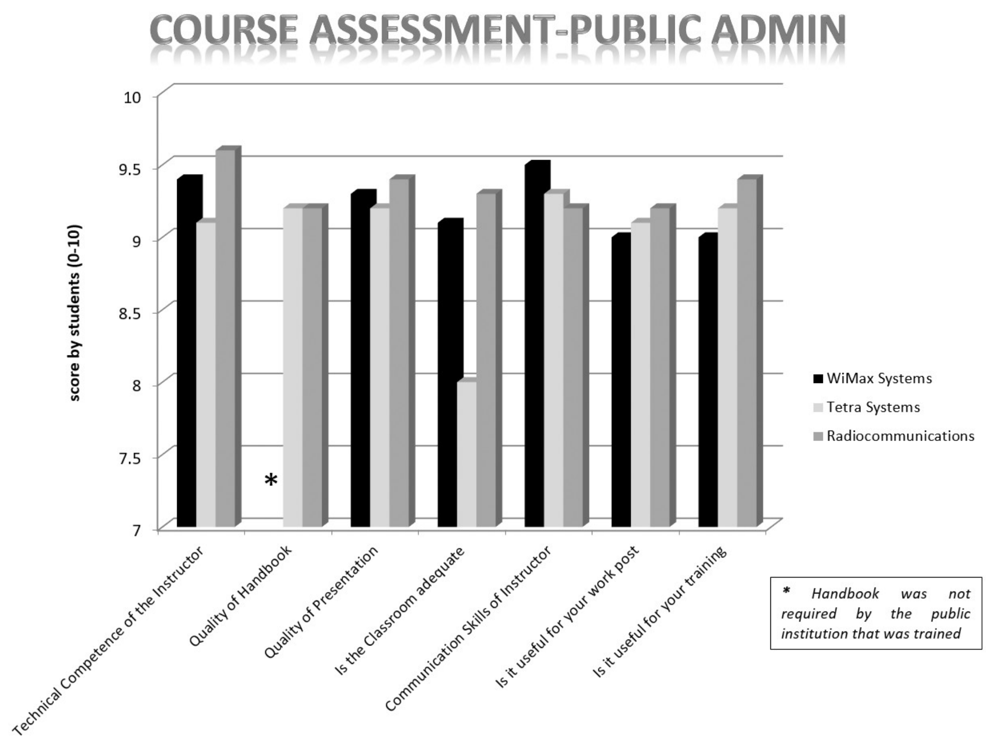


Fig. 8. Results of Course Assessment for courses given in industry (top Figure) and courses given within the framework of public administrations (bottom chart). Assessment is numerically expressed within the range 0–10.

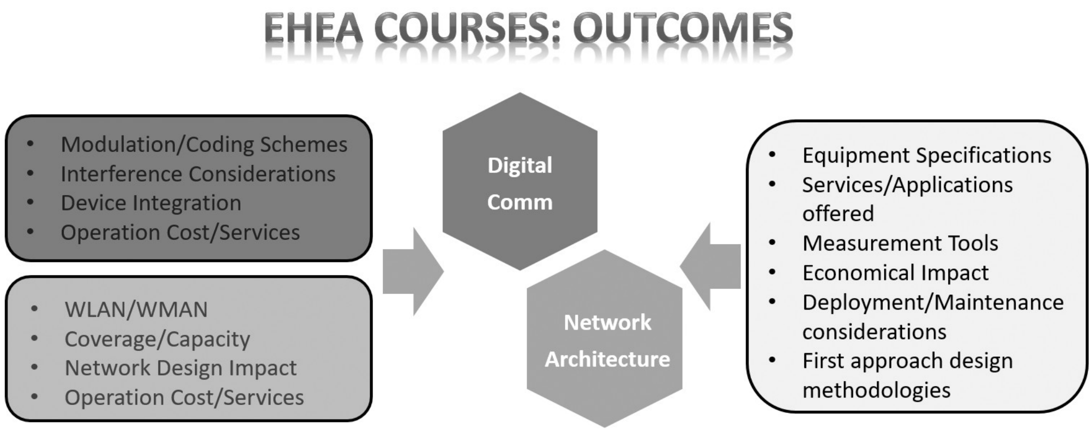


Fig. 9. Application of Feedback outcomes in the case of the Digital Communication course and the Network Architecture course. The left side of the Figure shows specific elements whereas the right hand side shows common items to be included in the contents and development of the courses.

way. The results of the different surveys are presented in Fig. 8.

The following outputs from the interaction with the students were obtained:

- Refreshing basic concepts or in some cases giving these basic concepts for the first time is highly motivating for the students. Many of them receive training highly focused on particular procedures or software tools that in general do not go into the underlying concepts.
- The use of methodological approaches such as case studies, group exercises or individual tasks helps to reinforce competences such as leadership or team playing. Moreover, the possibility of using reasoning skills to solve problems is also very positive for students.
- Using technical material not linked to a specific vendor or technology, but of more broad application is also a positive element of the courses that have been developed. University textbooks, research articles and technical documents from standards have been used and in many cases, students were strongly interested in increasing their knowledge by using this type of material.
- The adoption of a multidisciplinary approach is also considered useful by the students. Not only physical layer considerations are interesting in the case of wireless communications and radioplanning aspects, but also system level considerations and the way the system is deployed. A great deal of interaction was possible in the development of the courses between people in different functional areas. This gives rise to sharing experiences which are complementary and of great practical value for all of the students.

As a consequence of the information and the feedback obtained from both learning experiences, a simple set of outcomes and actions have been identified. They have been applied in both cases, focused in the University case in the adoption of practical skills and methods, whereas in the Industry/Administration case focused in the settlement of fundamental concepts and academic methodological approaches.

As an initial step in the application to the new EHEA courses, two courses have been identified for direct application of the interaction outcomes. They are Digital Communications and Network Architectures and were introduced previously in this section. The motivation for choosing these courses is based on the following points:

- Both courses require notions of wireless systems in order to fully achieve the competences the students should have once the courses have been taken by them.
- The courses can be of relatively broad scope within each one of the respective degrees in which they are integrated (Telecommunication Engineering, in the case of Digital Communications and Computer Engineering, in the case of Network Architectures). Therefore, it is natural to take a multidisciplinary approach.
- Both courses have laboratory exercises as well as individual and group case studies to be solved in the classroom. These elements are fundamental vehicles in order to introduce specifications, industrial methodological approaches, practical deployment considerations and techno-economic considerations, among others.

A schematic representation of the specific contents as well as the items derived from the feedback process is depicted in Fig. 9. For each one of the courses, specific items have been identified (left hand side of the Figure), whereas a common set of items have also been considered (right hand side).

4. Conclusions

The enhancement of the educational experience in Academia requires interaction with active actors in the productive world, such as Industry or Public Administrations. This statement also holds true in the case of Life Long Learning, in which experiences and lessons learned in Engineering Education can be a valuable resource to increase productivity and match in an optimal way industry requirements with personal expectations of the students.

In this paper, the interaction between Academia/ Industry has been analyzed by means of the development of courses in the particular case of wireless communications. Courses have been given in classical engineering degrees as well as in training sessions with Industry (Telefónica, telecommunications operator) and Public Administrations (Junta de Andalucía, Gobierno de Navarra). By analyzing the contents of each of these courses, as well as the feedback of the students (university students in one case and experienced workers in the other), outcomes from each one of the environments in relation with the other are given. In this way, a set of actions can be derived in order to bring closer together the expectations in the accomplishment of the competences to be acquired in the learning process with what industry demands. Moreover, the experience of the seasoned professionals is valuable in order to modify the teaching methodology to increase their motivation and hence the final productivity of the course. The results given by the assessment performed to students of all the levels and the different courses indicates that such interaction is positive for achieving the expected competences as well as to increase the overall satisfaction.

The interaction between Academia and Industry implies and is based on a continuous and collaborative reciprocal feedback, which can help in bringing closer together both environments. The results clearly show the benefits for students, professors and professionals and can be adapted to a wide variety of topics and degrees in a multidisciplinary way.

References

1. S. Adam, *Using learning outcomes, A consideration of the nature, role, application and implications for European education of employing 'learning outcomes' at the local, national and international levels*, Bologna Seminar, Edinburgh, United Kingdom, 1–2 July, 2004.
2. B. Jacobs and F. Van der Ploeg, Getting european universities into shape, *European Political Science*, **5**(3), pp. 288–303, 2006.
3. E. Coyle, Engineering Education in the US and the EU, Chapter 5 in Engineering in Context, *Academica*, 2009.
4. M. Murphy and E. Coyle, Engineering Leadership. In: Christensen S., Mitcham C., Li B., An Y. (eds) Engineering, Development and Philosophy, *Philosophy of Engineering and Technology*, **11**, pp. 341–356. Springer, Dordrecht, 2012.
5. J. Heywood, Assessing Performance in Engineering Education: Examples Across Fifty Years of Practice. In: Wimmers P., Mentkowski M. (eds) Assessing Competence in Professional Performance across Disciplines and Professions. Innovation and Change in Professional Education, vol. 13, pp 73–93, Springer, Cham, 2016.
6. European Commission, "Communication on recognition of qualifications for academic and professional purposes", presented to the Council and the European Parliament, December 1994.
7. G. Augusti, EUR-ACE®: A common European quality label for accredited Engineering Programmes, *International Conference on Engineering Education ICEE-2010*, Gliwice, Poland, July 18–22, 2010.
8. G. Augusti, EUR-ACE®, The European Model Of Accreditation Of Engineering Education: What Chances For Its Spread?, *Joint International IGIP-SEFI Annual Conference 2010*, Trnava (Slovakia), 19–22 September 2010.
9. E. Caporali, M. Catelani, G. Manfrida and J. Valdiserri, Environmental engineering education: examples of accreditation and quality assurance, *American Geophysical Union, Fall Meeting*, 2013.
10. E. Caporali, G. Manfrida, G. Bartoli and J. Valdiserri, Environmental issue through the international accreditation of engineering education, *International Conference on Interactive Collaborative Learning*, 20–24 Sept. 2015.
11. ABET, *The ABET criteria for accrediting engineering programmes*, 2019, www.abet.org.
12. ENAEE, *EUR-ACE Framework Standards for the Accreditation of Engineering Programmes*, 2015; www.enaee.eu [ENAEE Documents] (accessed 23/06/2019).
13. Bologna Working Group on Qualifications Frameworks, *A Framework for Qualifications of the European Higher Education Area* (QF-EHEA), 2005, www.ond.vlaanderen.be/hogeronderwijs/bologna/documents/QF-EHEA-May2005.pdf (accessed 23/06/2019).
14. B. Karseth and T. D. Solbrekke, Qualifications Frameworks: the avenue towards the convergence of European higher education?, *European Journal of Education*, **45**(4), November 2010.
15. Tuning Association, on behalf of a Group of Experts, *A Tuning-AHELO Conceptual Framework of Expected/Desired Learning Outcomes in Engineering*, OECD Education Working Papers, No. 60, OECD Publishing, 2011, http://tuningacademy.org/wp-content/uploads/2014/02/Tuning-AHELO_Engineering.pdf (accessed 23/06/2019)
16. K. Tremblay, OECD Assessment of Higher Education Learning Outcomes (AHELO). In: Blömeke S., Zlatkin-Troitschanskaia O., Kuhn C., Fege J. (eds) Modeling and Measuring Competencies in Higher Education, *Professional and Vet Learning*, **1**, pp. 113–126. Sense Publishers, Rotterdam, 2013.
17. European ministers of education, The European higher education area—Bologna declaration—, in *Joint Declaration of the European Ministers of Education*, Bologna, Italy, 1999.
18. K. Brøgger, The Infrastructure of the Bologna Process: Standards as Technology. In: Governing through Standards: the Faceless Masters of Higher Education, *Educational Governance Research*, **10**, pp. 87–138, Springer, Cham, 2018.
19. "European university association, Salamanca convention 2001," in *The Bologna Process and the European Higher Education Area*, Salamanca, 2001.
20. K. Brøgger, How education standards gain hegemonic power and become international: The case of higher education and the Bologna Process, *European Educational Research Journal*, **18**(2), pp. 158–180, 2018.
21. "European ministers of education, Towards the European higher education area," in *Commun. Meet. Europ. Ministers in Charge of Higher Education*, Prague, 2001.
22. C. Sugrue, Tone Dyrdal Solbrekke, Policy rhetorics and resource neutral reforms in higher education: their impact

and implications?, *Studies in Higher Education*, **42**(1), pp. 130–148, 2017.
23. ''European ministers responsible for higher education, The European higher education area—Achieving the goals—,'' in *Commun. Conf. Europ. Ministers Responsible for Higher Education*, Bergen, 2005.
24. B. Karseth and T. D. Solbrekke, Curriculum Trends in European Higher Education: The Pursuit of the Humboldtian University Ideas. In: Slaughter S., Taylor B. (eds) Higher Education, Stratification, and Workforce Development, *Higher Education Dynamics*, **45**, Springer, Cham, pp. 215–233, 2016.
25. S. Bergan and A. Rauhvargers, Eds., Recognition in the Bologna process: Policy development and the road to good practice, *Council of Europe Higher Education*, Series No. 4, 2006.
26. C. Sin, Intergovernmental Policies in Higher Education, Bologna. In: Teixeira P., Shin J. (eds) *Encyclopedia of International Higher Education Systems and Institutions*, Springer, pp. 1–4, Dordrecht, 2017.
27. K. Jæger, New-Style Higher Education: Disciplinarity, Interdisciplinarity and Transdisciplinarity in the EHEA Qualifications Framework, *Higher Education Policy*, pp. 1–20, 2018.
28. ''ECTS Users' Guide, European Credit Transfer and Accumulation System and the Diploma Supplement.'' Brussels, Belgium: Directorate-General for Education and Culture, 2005.
29. J. Kunze and A. Geyer-Schulz, ECTS Grades: Combination of Norm- and Criterion-Referenced Grading. In: Gaul W., Geyer-Schulz A., Schmidt-Thieme L., Kunze J. (eds) Challenges at the Interface of Data Analysis, Computer Science, and Optimization. Studies in Classification, Data Analysis, and Knowledge Organization. Springer, Berlin, Heidelberg, pp. 557–565, 2011.
30. H. Davies, The Recognition of Professional Qualifications: The Part Played by the European University Association in the Alignment of EU Legislation with the Bologna Process. In: Sin C., Tavares O., Cardoso S., J. Rosa M. (eds) European Higher Education and the Internal Market. Issues in Higher Education. Palgrave Macmillan, Cham, pp. 309–335, 2018.
31. L. Salas-Morera, J. Berral-Yerón, I. Serrano-Gómez and P. Martínez-Jiménez, An assessment of the ECTS in software engineering: A teaching experience, *IEEE Trans. Educ.*, **52**, pp. 177–184, Feb. 2009.
32. H. Ebrahiminejad, A Systematized Literature Review: Defining and Developing Engineering Competencies, ASEE Annual Conference & Exposition, Columbus, Ohio, June 2017. https://peer.asee.org/27526 (accessed 23/06/2019).
33. K. C. Welch, J. Hieb and J. A. Graham, Systematic Approach to Teaching Critical Thinking Skills to Electrical and Computer Engineering Undergraduates, *American Journal of Engineering Education*, **6**, pp. 113–123, 2015.
34. M. M. Pastor Artigues, F. Roure Fernández, M. Ferrer Ballester, J. Ayneto Gubert, M. Casafont Ribera, J. M. Pons Poblet and J. Bonada Bo, Learning in engineering through design, construction, analysis and experimentation, *International Journal of Engineering Education*, **35**(1), pp. 372–384, 2018.
35. E. Montero and M.J. González, Student engagement in a structured problem-based approach to learning: A first-year Electronic Engineering study module on heat transfer, *IEEE Trans. Educ.*, **52**, pp. 214–221, May 2009.
36. C. T. Orji and T. C. Ogbuanya, Assessing the effectiveness of problem-based and lecture-based learning environments on students' achievements in electronic works, *International Journal of Electrical Engineering & Education*, **55**(4), pp. 334–353, 2018.
37. A. Mantri, Working towards a scalable model of problem-based learning instruction in undergraduate engineering education, *European Journal of Engineering Education*, **39**, pp. 282–299, 2014.
38. C. Efrén Mora, B. Añorbe Díaz, A. M. González Marrero, J. M.Gutiérrez and B. D. Jones, Motivational Factors to Consider when Introducing Problem-Based Learning in Engineering Education Courses, *International Journal of Engineering Education*, **33**(3), pp. 1000-1017, 2017.
39. R. Magdalena, A. J. Serrano, J. D. Martín-Guerrero, A. Rosado and M. Martinez, A teaching laboratory in analog electronics: Changes to address the Bologna requirements, *IEEE Trans. Educ.*, **51**, pp. 456-460, Nov. 2008.
40. O. V. Stukach and A. B. Mirmanov, Integrative Approach to Teaching of the Circuit Design of Analog Electron Devices in the NI ELVIS Platform, *Open Education*, **22**, pp. 4, 2018.
41. Vianney Lara-Prieto, Jacob de la Cruz-Hinojosa, Eduardo J. Arrambide-Leal, Francisco Palomera-Palacios, M. Ileana Ruiz-Cantisani and Juan Manuel Campos-Sandoval, First-year Engineering Students Engagement by Hands-on Experience with Star Wars Robotics, *IEEE Global Engineering Education Conference (EDUCON)*, Dubai, United Arab Emirates, 8–11 April 2019.
42. F. Soltani, D. Twigg and J. Dickens, Setting up University-Industry Links through Sponsoring Undergraduate Engineering Programs, *International Journal of Engineering Education*, **28**(3), pp. 572–578, 2012.
43. A. Lopez-Martin, P. Sanchis, G. Perez-Artieda, E. Gubia, D. Morato, D. Astrain, E. Barrenechea, J. Lopez Taberna and I. R. Matias, New organizational and assessment frameworks for company internship programs, *IEEE Global Engineering Education Conference (EDUCON)*, Athens (Greece), 25–28 April 2017.
44. A. Lopez-Martin, P. Sanchis, G. Perez-Artieda, E. Gubia, D. Morato, D. Astrain, E. Barrenechea, J. Lopez Taberna and I. R. Matias, Evaluating engineering competencies in curricular internships, *IEEE Global Engineering Education Conference (EDUCON)*, pp. 1652–1658, 2018.
45. R. Zavbi and N. Vukas Inovic, A Concept of Academia–Industry Collaboration to Facilitate the Building of Technical and Professional Competencies in New Product Development, *International Journal of Engineering Education*, **30**(6B), pp. 1562–1578, 2014.
46. A. G. Ball, H. Zaugg, R. Davies, I. Tateishi, A. R. Parkinson, C. G. Jensen and S. P. Magleby, Identification and Validation of a Set of Global Competencies for Engineering Students, *International Journal of Engineering Education*, **28**(1), pp. 156–168, 2012.
47. M. Henri, M. D. Johnson and B. Nepal, A Review of Competency-Based Learning: Tools, Assessments, and Recommendations, *Journal of Engineering Education*, **106**(4), pp. 607–638, October 2017.
48. J. Watson and J Lyons, Aligning Academic Preparation of Engineering Ph.D. Programs with the Needs of Industry, *International Journal of Engineering Education*, **27**(6), pp. 1394–1411, 2011.
49. F. Falcone, A. Alejos, P. Sanchis and A. Lopez-Martin, Enhancing the Development of Multidisciplinary Skills in Engineering Students by Promoting Industry and University Synergy, *International Journal of Engineering Education*, **30**(6B), pp. 1657–1668, 2014.
50. M. Indhira M. Hasbún, H. M. Matusovich and S. G. Adams, The Dissertation Institute: Motivating doctoral engineering students toward degree completion, *IEEE Frontiers in Education Conference (FIE)*, Erie, PA, USA, 12–15 Oct. 2016.
51. C. Martinez-Mediano and S. M. Lord, Lifelong Learning Competencies Program for Engineers, *International Journal of Engineering Education*, **28**(1), pp. 130–143, 2012.
52. R. M. Marra, S. M. Kim, C. Plumb, D. J. Hacker and S. Bossaller, Beyond the Technical: Developing Lifelong Learning and Metacognition for the Engineering Workplace, *ASEE Annual Conference & Exposition*, Columbus, Ohio, USA, 25-28 June 2017. https://peer.asee.org/27659.pdf (accessed 23/06/2019).
53. S. S. Guzey, E. A. Ring-Whalen, M. Harwell, et al., Life STEM: A Case Study of Life Science Learning Through Engineering Design, *International Journla of Science and Math Education*, **17**(1), pp. 23–42, January 2019.
54. K. S. Ibwe, E. A. Kalinga and N. H. Mvungi, Tenhunen, Hannu The impact of industry participation on challenge based learning, *International Journal of Engineering*, **34**(1), pp. 187–200, 2018.

Francisco Falcone received his Telecommunications Engineering Degree (1999) and PhD in Communications Engineering (2005), both at the Universidad Pública de Navarra (UPNA) in Spain. From 1999 to 2000 he worked as Microwave Commissioning Engineer at Siemens-Italtel. From 2000 to 2008 he worked as Radio Network Engineer in Telefónica Móviles. In 2009 he co-founded TafcoMetawireless, a spin off devoted to complex EM analysis. From 2003 to 2009 he was also Assistant Lecturer at UPNA, becoming Associate Professor in 2009. He is currently Head of the Department of Electrical and Electronic Engineering at UPNA. His research area is artificial electromagnetic media, complex electromagnetic scenarios and wireless system analysis. He has over 280 contributions in journal and conference publications. He has been recipient of the CST Best Paper Award in 2003 and 2005, Best PhD in 2006 awarded by the ColegioOficial de Ingenieros de Telecomunicación, Doctorate award 2004–2006 awarded by UPNA, Best Internal Instructor of Telefonica in 2008, Juan Lopez de Peñalver Young Researcher Award 2010 awarded by the Royal Academy of Engineering of Spain and PremioTalgo 2012 for Technological Innovation. He is Senior Member of IEEE, collaborating with the IEEE Education Society Chapter in Spain from 2006 to 2011.

Ana Vazquez Alejos received the M.S. degree from University of Vigo, Spain, in 2000. She has completed her Ph. D. thesis on the radio channel characterization for the millimeter wave frequencies, working in the band of 40GHz, in 2006. Since 2000, she has been working at the Departamento de Teoría de la Señal y Comunicaciones, University of Vigo, as research and teaching staff. Her Master Thesis received in 2002 the Ericcson Award by the ColegioOficial de Ingenieros de Telecomunicación (COIT), the Spanish Association of Electrical Engineers, as the best Multimedia Wireless Project. Her research work includes radio propagation, communication electronics, wideband radio channel modeling, multimedia wireless systems, waveform and noise code design, and radar. She has been granted with the Marie Curie International Outgoing Fellowship, and she is carried out the outgoing phase in the New Mexico State University (NM, USA), at the Klipsch School of ECE, with a research focused on measurement and modeling of propagation through dispersive media, and radar waveform generation. At present, she returned back to the University of Vigo, Spain, with a further research in dispersive propagation. Dr. Alejos has also accomplished research in engineering education published in different journal papers and book chapters. Dr. Alejos is a reviewer for several IEEE, and IET journals as well as international conferences. Since 2011, she is also the America Regional Correspondent for the IEEE Global Communications Newsletters.

Javier García Cenoz received his Telecommunications Engineering Degree (2008) from the Universidad Pública de Navarra (UPNA) in Spain. Since 2000he works as Radio Network Engineer in Telefónica Móviles, in Mobile Radio Network Planning and Optimization for a variety of different access technologies. Since 2006 he is also Assistant Lecturer in the Electrical and Electronic Engineering Department at UPNA.

Antonio López-Martín received the M.S. and Ph.D. degrees (with honors) from the Public University of Navarra, Pamplona (Spain) in 1995 and 1999, respectively. He has been a visiting professor with the New Mexico State University, Las Cruces, NM, and an invited researcher with the Swiss Federal Institute of Technology (ETH), Zurich. Currently, he is an Associate Dean and Professor with the Public University of Navarra, and an Adjunct Professor with the New Mexico State University. His current research interests include wireless communications low-power microelectronic design. He has published more than 300 technical contributions in books, journals, and conferences. He also holds 6 international patents, leads various research projects and is consultant for local companies. Dr. Lopez is currently serving as an Associate Editor of the IEEE Latin-American Journal of Learning Technologies (RITA) and other technical journals. He was an Associate Editor of the IEEE Transactions on Circuits and Systems-I (2008–2009) and IEEE Transactions on Circuits and Systems-II (2006-2007). He is also in the technical committee of various conferences. His recent awards include the Talgo Technological Innovation Award in 2012, the ANIT's Engineer of the Year Award in 2008, the Caja Navarra Research Award in 2007, the Young Investigator Award from the Complutense University of Madrid in 2006, the 2005 IEEE Transactions on Education Best Paper Award, and the European Center of Industry and Innovation (CEIN) Award in 2004 for excellence in transfer of research results to industry.