

Available online at www.sciencedirect.com

Procedia Social and Behavioral Sciences 2 (2010) 1368–1378

Procedia
Social and Behavioral Sciences

WCES-2010

Project-based learning in engineering higher education: two decades of teaching competences in real environments

Ignacio de los Ríos^a, Adolfo Cazorla^a, José M. Díaz-Puente^a, José L. Yagüe^a *^aTechnical University of Madrid, Escuela Técnica Superior de Ingenieros Agrónomos, Avenida Complutense s/n., Madrid, 28040 Spain

Received October 12, 2009; revised December 21, 2009; accepted January 6, 2010

Abstract

This paper presents an educational methodology of cooperative project-based learning. This methodology emerges in the final years of the undergraduate programme of the Technical University of Madrid. The paper focuses on the evolution of this experience up to its insertion in the European Higher Education Area (EHEA), incorporating the project management competences of the International Project Management Association (IPMA) and broadening its scope to an entire educational strategy for undergraduate and graduate programmes. The results show how the methodology provides three main advantages: (1) it facilitates training in technical, personal, and contextual competences; (2) real problems in the professional sphere are dealt with; and (3) collaborative learning is facilitated through the integration of teaching and research.

© 2010 Elsevier Ltd. Open access under [CC BY-NC-ND license](http://creativecommons.org/licenses/by-nc-nd/3.0/).

Keywords: Project-based learning; competence-based training; engineering higher education; personal competences; collaborative learning.

1. Introduction

Currently, we are involved in a wide-reaching process of reflection and change oriented toward promoting a qualitative leap in the educational model of the universities of the European Union stemming from different agreements reached in the EU to construct a European Higher Education Area (EHEA) to be the basis of a new knowledge-based economy that responds to the challenges of globalization. Outstanding among these agreements are the Sorbonne Declaration (Allegre et al., 1998), the Bologna Declaration (1999), The Lisbon European Council (European Council, 2000), and the Berlin Declaration on Open Access to Knowledge in Sciences and Humanities (Berlin Communiqué, 2003). The Bologna Declaration is particularly a key document, which marks a turning point in the development of European higher education. It was signed by 29 countries which assume the challenge to attain the Declaration's objectives and, to that end, engage in coordinating their policies.

However, the starting point of any strategy in this sense should be a clear notion of the end goal and of the functions of the university. Whatever model is adopted, one thing should remain unaltered in the university institution: 'the incessant search for truth in which the teacher teaches what he discovers day to day, subjecting his own knowledge to permanent criticism, with a marked vocation for service to the society in which he is immersed' (Cazorla & De los Ríos, 1998).

*José M. Díaz-Puente. Tel.: +34-91-336-3986; fax: +34-91-336-6214

E-mail address: jm.diazpuente@upm.es

It is for this reason that the aptitudes and abilities that society demands of its future professionals constitutes a fundamental aspect that should be considered in the design of any educational strategy. Technological, economic, social, cultural and political changes define new profiles in view of what the enterprises need from their professionals. In a society characterized by a wide range of approaches, aspects never before considered are being discovered. To solve the enterprises' problems, technology is not enough; rather more humanism is necessary. The need for innovation and flexibility continue to be at the forefront, and appearing as values rising in importance are creativity, initiative and risk-taking (Sáenz de Miera, 1997). For many years enterprises have pointed out the following aspects as the main deficiencies in university education: insufficient preparation for research and creation; excessively theoretical instruction with a reduced practical component; knowledge that is too general with deficient specialization and updated knowledge; and meagre preparation in directing human teams (Ministerio de Educación y Ciencia, 1985). One of the great challenges of the university system is to demonstrate capacity for adaptation to the changes in today's society and its new demands, in which the concept of profession focuses on what are called professional competencies.

In this new context, the conception of competencies constitutes the essential foundation in the professional world, and therefore, it becomes a key element of any educational model. Today, enterprises demand, more than experimented experts, competent professionals. Moreover, in the sphere of the EHEA it is stressed that one of the measures necessary for achieving employability is developing transversal skills and competencies, such as communication and languages, the ability to handle information, to solve problems, to work in teams, and to lead social processes (Convención de Instituciones Europeas de Enseñanza Superior, 2001).

Competence is an amplification of the concept of ability and qualification resulting from the rapid technical evolution in the organization of work and planning activities (Grootings, 1994). The competence of professional action (Delcourt, 1999) is thus the sum of the competences essential to carrying out a professional task well (Echeverría, 2002).

Within this general framework, numerous studies around the world have proposed project-based learning (Chinnowsky et al., 2006; Gijsselaers, 1996; Johnson, 1999; Padmanadhan & Katti, 2002) as the most suitable means of achieving effective competence-based education (Parsons et al., 2005; Mulcahy, 2000; Kelly, 2007) that integrates knowledge, skills and values. The models integrating project-based learning have their scientific basis in generating learning processes in which students are not passive recipients of knowledge (Chinnowsky et al., 2006). Following the trends in psychology of knowledge, project-based learning is grounded in the belief that humans construct new knowledge over a base of what we already know (Gijsselaers, 1996) and of what we have experienced, which we make available through active participation and interaction with others.

This paper presents a methodology of cooperative education, which was applied over 20 consecutive years and which integrates the scientific basis of project-based learning. Over this extended period, we were able to extract the main advantages and difficulties that have appeared during the process, from its initial phase as an innovative pilot experience in an undergraduate course, up to its consolidation within an entire educational strategy completely adapted to EHEA and that covers both undergraduate and graduate programmes.

2. Project-based learning: phases of an experience

In 1987 an educational methodology was first applied with students of the fifth year of the programme of the Agronomic Engineer Technical School of the Technical University of Madrid (Universidad Politécnica de Madrid), fruit of a collaboration agreement for integrated studies in development of the region between the ETSIA Department of Projects and Rural Planning and the Government of the Community of Madrid. This agreement and the subsequent projects implemented in the course of twenty years were the foundation for consolidating the project-based learning approach that has permitted adapting methodological aspects developed in teaching to real problems (Cazorla, Marco & De los Ríos, 1990).

An initial teaching method, as a logical set of procedures that tend to direct students' learning (Sánchez Núñez, 1996), gave way to evolution of a broader concept that has incorporated other different educational methods. This integration of methods motivated the current use of the concept of learning strategies, merging different methods—intuitive, comparative, deductive, case study, problem-solving—(Cazorla & De los Ríos, 1996) and different activities inside and outside the classroom—lecture, group activities, cooperative learning, online and face-to-face tutoring, project exhibits, competitions among project teams, etc.—and covering both undergraduate and graduate levels.

In the following section, the evolution of the project-based learning experience is reviewed. Through the twenty years of development, three broad phases are identified together with their methods, activities and support elements that have been progressively incorporated, as well as the problems and difficulties encountered.

2.1. First phase (1987-1996): ground breaking and validation of the methodology

At the core of the learning methodology is the student, who, with a small group, plans, designs and evaluates a project that responds to a real need posed by the client—in this case the Regional Government of Madrid. The students are coordinated by the professor in charge of the course ‘Projects’ (Cazorla & De los Ríos, 1996). For this learning process, students are required to use different sources of information and delve into knowledge from different disciplines to solve concrete problems.

Students developed a novel activity called pre-professional experience, based on the idea of learning by doing—learn from reality itself and from there extract relevant knowledge (Cazorla & De los Ríos, 1996). Although the initiative began in the Projects Department of the UPM, we were able to convince the heads of Regional Administration Services of the mutual enrichment the agreement would produce.

In this first phase, from the perspective of consolidating the learning process, besides lectures—presentations based on symbolic methods where knowledge is displayed through oral and written language—the intuitive method is highlighted (Sánchez Núñez, 1996). This method is necessary for completion of the coursework and is based on the construction of new knowledge from direct experience of the student, procuring to approximate teaching to reality. This is one of the main elements of the strategy: participation in projects and protocols with real content which responds to real needs, giving students the opportunity to leave the classroom to solve problems directly with external agents. The educational process is assumed to have a dynamic element in which students learn to learn about the reality of the rural world and how the Public Administration—project client—works (Cazorla & De los Ríos, 1996).

In the coordination of the project-based learning activities, a method of logic is applied, in which learning experiences respond to structuring in phases of the methodologies of project formulation and evaluation. The course is basically a process aimed to teach methodologies that show ways to carry out work, and that have an organic process in which one concept is linked to another. Thus, for example, the conceptual aspects of project evaluation are approached through learning activities based on the evaluation of real posed problems.

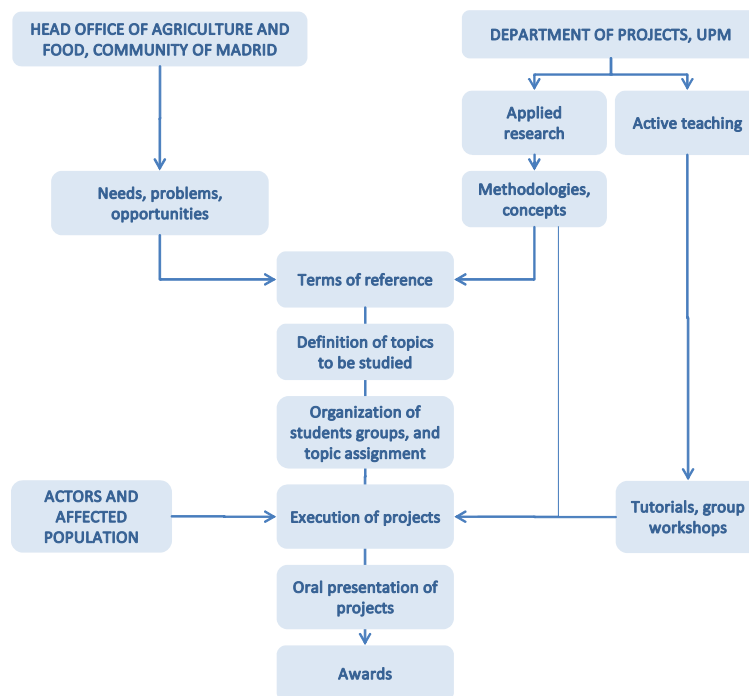


Figure 1. Actors and methodology centred in project-based learning (phase I)

Figure 1 shows all of the actors involved and the basic work methodology for carrying out the projects with the students. Firstly, the planning team—the Department of Projects of the university—is in an intermediate position between the project clients—the technical teams of the Head Office of Agriculture and Food (Dirección General de Agricultura y Alimentación) of the Community of Madrid—and the beneficiaries of the projects—the population that lives in the rural areas. Secondly, the students are inserted into this framework to participate in a learning process, solving real problems in teams. During this process, students are enriched with external knowledge extracted in direct contact with diverse people: service department heads and administrative personnel, farmers, extension agents, city councillor, representatives of local action groups, local development agents. Participation of the local population in the process of formulating projects and adapting rural development policies, plans and programmes for the community of Madrid is fundamental for this work. These relationships and complementary information enrich the students' base knowledge to construct new knowledge. The process is coordinated and tutored by the professors of the Department of Projects of the UPM (Cazorla & De los Ríos, 1996).

The process of approximation to reality is complemented with group activities in class and participatory workshops using active methods (Johnson, 1999) to achieve direct participation of the students in the development of the projects, in a way similar to real professional work. In these sessions the professor acts as a guide in the tasks students undertake and provides incentive for learning. With these sessions, an active learning process is obtained instead of a passive absorption of knowledge. The active method of learning by doing (Bartkus, 2001; Hackett, Martin & Rosselli, 1998; Johnson, 1999) is of special relevance in the area of projects with enormous potential for originality, creativity and common sense that can fit perfectly with the scientific and technical knowledge students have previously received during their coursework.

At the end of the class period, different teams of students present and defend their projects and studies before teachers and heads of the regional administration. All of them receive a small sum of money; the best project receives more. With this, competitiveness among the teams is promoted; as in the real professional world, they must produce better technical work to 'sell' to a client.

From the start, the experience includes two complementary aspects: teaching and applied research. From the results of given multidisciplinary actions—applied research—new knowledge is generated and applied in teaching. This enriches the professional formation of the professor-researcher and the learning processes.

However, it must be pointed out that during this initial phase there were two types of problems. On one hand, it was necessary to overcome certain attitudes of the authorities of the administration who see the university as an entity removed from reality that can contribute little to solve problems of the professional world. To initiate this novel methodological process, it was assumed that people would be open and trust the change and the fruits of cooperative learning to learn from reality itself and extract new knowledge. On the other hand, because the initiative originated in the university, it was necessary to hold numerous meetings with the people in charge of Technical Services of the community of Madrid to make them understand the educational aims and the mutual enrichment that could be produced through an agreement between the university and the public administration.

Another great difficulty appeared in the classroom: students were unaccustomed to undertake tasks with real content. The lack of motivation among the students was one of the great challenges; a large part of the problem of learning to think—and thought—is a problem of motivation. Thinking can be hard work and undoubtedly the main reason that people do not think is simply because they are unwilling to make the effort (Nickerson, Perkins & Smith, 1985). The main ingredients of the solution to overcome this obstacle and motivate the students were the eminently practical approach, contact with real agents and performing useful work that solves real problems.

2.2. Second phase (1996-2003): expansion to other courses and incorporation of support elements

After the first nine years in which the strategy was validated, the change in curriculum in our university in 1999 constitutes the beginning of a second phase in which the application of the methodology was extended to the course 'Projects in Integrated Rural Development'. In this way, project-based learning is used simultaneously in 4th year—common core Projects course—and 5th year—elective course 'Projects in Integrated Rural Development'—and in the specializations in Territorial Planning, Environment, Agricultural Economics and Rural Engineering. The methodological basics and the philosophy of the agreement with the public administration of Madrid continue to exist, but the accumulated lessons permitted enrichment of some of the activities, while the change from a year-long course to one of four months required certain adjustments. Also, the objectives of the agreement are complemented, allowing the inclusion of students to carry out

their Final Project (a short thesis required for graduation) in collaboration with a public or private organism and in contact with a multidisciplinary group that includes university professors.

Table 1. Basic data on the three phases of project-based learning methodology application

	1st Phase (1987-1995)	2nd Phase (1996-2003)	3rd Phase 2004 – present
Study Plan ETSI Agronomists UPM	1974	1996	1996 and EHEA
Courses	Projects (common core 5th year)	Projects (4th year) Projects in Integrated Rural Development (5th year)	Projects (4th year) Projects in Integrated Rural Development (5th year)
Project-based learning course	5th year	4th and 5th year	4th and 5th year
Student specializations	Agricultural Economics	Agricultural Economics Territorial Planning Environment Rural Engineering	Agricultural Economics Territorial Planning Environment Rural Engineering Engineering Projects Economics, Sociology and Agrarian Policy Urbanism and Territorial Planning
Areas of knowledge	Engineering projects	Engineering Projects Economics, Sociology and Agrarian Policy Urbanism and Territorial Planning	Engineering Projects Economics, Sociology and Agrarian Policy Urbanism and Territorial Planning
Client	Dirección General de Agricultura (Community of Madrid)	Dirección General de Agricultura y Desarrollo Rural (Community of Madrid)	Dirección General de Agricultura y Desarrollo Rural (Community of Madrid)
Competences	Personal techniques	Personal techniques	Personal contextual techniques
Client annual economic resources	600 euros	6000 euros	7000 euros
Project-based learning approach	Yes	Yes	Yes, adapted to IPMA competences in the office of Projects
Award to Final Project	No	Yes	Yes

Like in the previous phase, some activities are posed with the case study method using an inductive approach (Sánchez Núñez, 1996). Real situations are presented by the department of projects; debates are held and exercises related to different phases of the methodology of project formulation and evaluation are given. These sessions, in which students must observe and analyse facts, help students to link theory with reality.

Table 2. Evolution of the relative weight of activities in the three phases of the project-based learning methodology

Types of activities in the project-based learning methodology	Class time		
	1 st Phase	2 nd Phase	3 rd Phase
Lectures (supported by transparencies or Power Point presentations, with the symbolic method to present concepts) (symbolic method)	40	30	20
Final group work outside the classroom for development of projects (project-oriented learning, following the intuitive method)	20	25	28
Group activities in class and participative workshops for the course project (active method)	5	10	20
Cooperative learning activities for group interdependence (analogical or comparative method)	0	4	10
Learning activities based on problems (problem-solving in student teams) (intuitive method)	20	8	6
Activities pertinent to the case study method (a real situation is presented to be solved by teams of students in a given period of time)	6	4	0
Support from information technology (moodle platform and distance teaching)	0	10	15
Group tutoring for course projects.	60	50	20
On-line tutoring for course projects.	0	0	20

Types of activities in the project-based learning methodology	Class time		
	1 st Phase	2 nd Phase	3 rd Phase
Presentations of project advances and final results.	10	12	15
Total hours of student work.	161	153	154

In terms of the course syllabus, the content of the units are approached with greater flexibility, and an enriching exchange of opinion is encouraged. For the presentations of projects, an environment is created to favour free expression of students' original ideas and thus foster creativity. Table 2 reflects how, in this phase, a point of inflection is produced in the type of activities which primes for those of the collective type and those that are supported by new technologies. The following are some of the main novelties:

- Some sessions are introduced with cooperative learning activities (Johnson, 1999), using the analogical or comparative method, which aims to increase interdependence among the groups, to establish comparisons of project situations, and to come to new conclusions. For example, occasionally, students analyse the differences in the way to deal with the phases and partial results of the project.
- Teaching is aided by information technology in the form of a web platform-Aulaweb. In this phase online teaching support is simply an element to improve communication between students and professors, without activities of self-evaluation.
- The good results of the first phase led to the introduction of a new link with the client: an award for the best projects or viability studies for the community of Madrid presented by students as Final Projects. A joint committee formed by representatives of the client—the Dirección General de Agricultura y Alimentación de la Comunidad de Madrid—and of the Departamento de Proyectos y Planificación Rural de la Universidad Politécnica de Madrid award the prize of a monetary sum to the best work. In this way, as in the professional world, team competitiveness is promoted.

During this phase a number of structural problems were encountered, mainly adjusting annual course credits and teaching hours to those of a four-month session and the lack of classrooms suitable for cooperative learning activities and group interdependence.

Also, many of the platforms for supporting teaching with information technology, which began at that time in the UPM, were in an experimental stage and the teachers in a period of training. This caused technical problems for many activities and use of this means was incipient and gradual. Thus, the creation of GATE—Gabinete de Tele Educación de la UPM—was important in providing a support service for these activities for educational innovation in general.

Table 3. Topics of projects carried out under the project-based learning methodology

Project-based learning topics	Num. of projects by area	
Diversification of agriculture	New uses	9
	Rural tourism and handicrafts	6
	Ecological products	4
	Development of quality products	5
	Creation of cynegetic farms	1
Ex-post evaluation of rural development projects	Production planning	7
	LEADER initiative	6
	Basic infrastructures	3
Basic infrastructure for development	Livestock routs and rural roads	8
	Livestock infrastructures	7
	Irrigation	5
	Plot concentration	4
	Integrated rural development	3

Project-based learning topics	Num. of projects by area	
	Historic irrigation	1
Improvement of rural habitat	Development in rural zones	5
	Rehabilitation of degraded areas	4
Potentiation of agriculture	Improvement of commercialization	3
	Modernization of production units	6
	Quality products	4
Natural resources and environment	Conservation of natural spaces	4
	Agroenvironmental measures	5
Development planning in rural territories	Territorial planning	4
	Governance in rural territories	5
	Agroenvironmental measures	6
Total number of projects carried out		115

2.3. *Third phase (2003-present): an educational strategy linked to competences in project management*

This phase is inserted into a full process of adaptation of the university to EHEA, consequent with the challenge of converting the European Union into a society based on more competitive and dynamic knowledge. This demands new models of educational innovation based on competences and aptitudes; it implies new course designs and new learning objectives, affecting both teaching-learning methodologies and evaluation.

In this context the concept of ‘life-long learning’ emerges (European Council, 2000; Commission of the European Communities, 2001; 2003); the concept is understood as any learning activity carried out throughout life with the aim of improving knowledge, competences, and aptitudes under a personal, civic, social or job-related perspective (Commission of the European Communities, 2000). In Spain, planning of official university educationⁱ mentions the need to include general and specific qualification competences for higher education. In a number of disciplines—not only technical—certain competences necessary for problem-solving require a global vision to be able to combine and administer all the resources needed to transform an idea into reality.

Definitely, this new focus of higher education requires that the universities begin methodological changes with approaches oriented toward evaluation of competences. In our experience, during the 2004-05 school year and after the phase of consolidating project-based learning, a methodological change was advocated in which learning and evaluation were oriented toward competences relevant to the field of Project Management (Cazorla et al., 2007; De los Ríos et al., 2006). In fact, this will be integrated as a pilot experience in the process of implanting the EHEA in the area of projects through an educational innovation group which will facilitate changes in this new phase.

To implement the change, it was believed that the most suitable way was to adopt a professional referent that would represent the needs of society. Thus, the standard of the International Project Management Association (IPMA)ⁱⁱ was adopted. This organization is integrated by more than forty national professional associations from the entire world, especially Europe. In this sense, adoption of this standard enabled initiation, in its university stage, of specialized training of future professionals with more opportunities in the outside world.

Long title	Capabilities	Certification Process			Validity	
		Stage 1	Stage 2	Stage 3		
Certified Projects Director	Competence = knowledge + experience	A	Application, Curriculum vitae, self-assessment, references, project list	Projects director report	5 years	
Certified Senior Project Manager		B		Project report		Interview
Certified Project Manager		C		Exam, options		
Certified Project Management Associate	Knowledge	D	Application, Curriculum vitae, self-assessment	Exam		

Figure 2: IPMA Four level certification system

The IPMA certification schemes (See Figure 2) and systems of the certification bodies—as defined in the UNE-EN ISO/IEC 17024 (2003)—are an incentive for the project managers and the members of the project management teams (i.e. the project management personnel) to expand and improve their technical, behavioural and contextual Project Management (PM) competence, continue their education and experience in PM, improve the quality of PM, and last but not least, achieve the project, programme and portfolio objectives better (IPMA, 2008). The system of certification is organised around four levels (See Figure 2) regulated by the IPMA Competence Baseline (ICB). This guide combines all of the elements of Project Management competencesⁱⁱⁱ organised in three spheres: technical, behavioural, and contextual competences (AEIPRO-IPMA, 2006), and contains fundamental terms, tasks, practices, skills, functions, management processes, methods, techniques and tools that are commonly used in project management, as well as advanced knowledge, where appropriate, of innovative and advanced practices used in more limited situations.

The methodology tested up to now, following the project-based learning approach, has met this standard perfectly: the students conduct a pre-professional experience connecting elements of technical and contextual competences in the sphere of rural development projects with the needs of the productive sector and real problems of the countryside. From an educational point of view, elements of personal competences are also developed: teamwork, communication, leadership, commitment and motivation, self-control, self-confidence, openness, creativity, outcome orientation, efficiency, values, and the capacity for adaptation and innovation in problem solving (Cazorla et al., 2007; De los Ríos et al., 2006).

Sessions based on the deductive method are introduced; in these sessions elements of contextual competences are presented, and from these elements, the relationships to other elements of competence are extracted. For example, from the ‘project-oriented’ and ‘programme-oriented’ competences, relationships are established with concrete ‘project implementation’ and ‘permanent organisations’ of a given rural area.

With this approach, activities are undertaken that reinforce the globalisation of knowledge in the sense that different disciplines are integrated—economics, sociology, agrarian policy, environmental sciences, territorial planning, project engineering—consistent with the needs that arise as contextual competences of project management. In this way, teaching units are not treated in isolation, but present a relationship among the three dimensions of competence: technical, behavioural and contextual.

Finally, it is in this phase when the use of Information and Communication Technologies (ICT) is consolidated as online support for teaching and for the processes that improve communication among students and tutors. With this means of communication, tutoring acquires two components: face-to-face and online. The experience shows that the

combination of the two components in project-based learning improves the process of communication and contributes complementary information as students’ activities and learning progress.

3. Constitution of an integrated educational strategy

In its third phase, the methodology is supported by a new work structure. In the previous phases, work pivoted directly and exclusively around the professors involved in the courses. Now, these professors are members of the Educational Innovation Group (GIE-project) and of a research group; both structures are recognized, regulated and supported by the UPM and include other professors and researchers.

The first, GIE-project, has as its main objective to conceive a new teaching dimension of the students’ final project as an educational element to generate a pre-professional experience, which also reinforces cooperative learning (Bartkus, 2001; Hackett et al., 1998), and gradually covers the 46 elements of IPMA competence.

The second group, the Research Group in Planning and Sustainable Management of Local Rural Development (Grupo de Investigación en Planificación y Gestión Sostenible del Desarrollo Rural Local, GESPLAN, UPM), conducts applied research that complements teaching and broadens the scope of graduate studies. This has brought about a substantial change: more or less independent courses become part of an entire educational strategy focused on project management competences through project-based learning (See Figure 3).

In this way, teaching and research are integrated in a scheme of four levels, similar to the IPMA certification model, which gradually provides escalated training to students in the three spheres of competence. Their knowledge increases and their attitudes are shaped as they journey over this educational ‘road’; they are given opportunities to acquire certain basic experience in advance, beginning with course projects that have been the basis of this methodology.

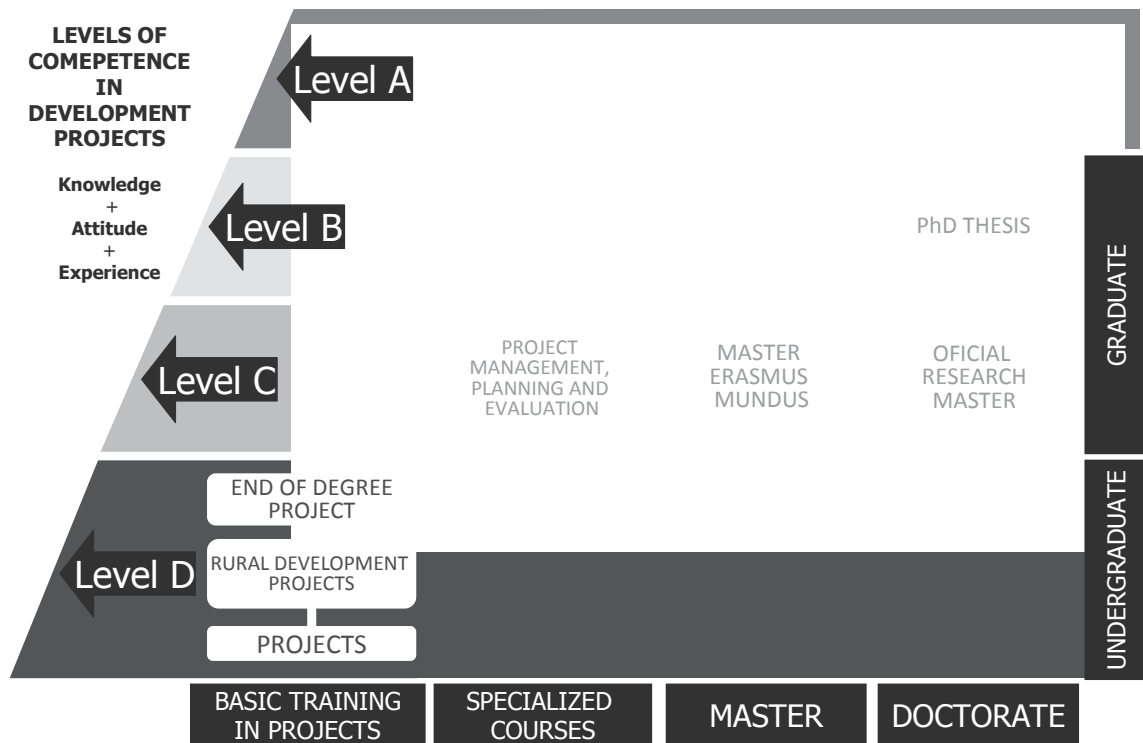


Figure 3. Educational strategy in the area of development projects. GESPLAN-UPM

The graduate level includes an Erasmus Mundus International Master, in cooperation with six universities of the EU and another nine universities outside the EU, and a doctoral programme adapted to the Bologna agreement and linked with a research masters which has received official recognition. Since 2006, the strategy also incorporates a

graduate seminar in project management held in collaboration with two engineering companies and approved by the Spanish Association of Project Engineering (Asociación Española de Ingeniería de Proyectos, AEIPRO).

In undergraduate courses the twenty elements of technical competence, fundamental for project management, are given more weight. At the graduate levels, the eleven elements of competence related to project context and organization are examined in greater detail.

Perhaps the most important problems encountered during this phase are those relative to adaptation of the guiding principles and contents offered at the graduate level to the new scheme of project management competences. This has required much effort to make all of the teachers involved aware of the need to change for adaptation to EHEA and especially of the opportunity that adopting a recognized professional standard offers. In general, we can say that reluctance to open up to the professional world continues to exist and even more so to use it as a referent for designing teaching content.

4. Conclusions

The 20-year experience with project-based learning described here is presented as the most adequate educational methodology for the development of competences, linking teaching with the professional sphere. This learning technique is based on cooperation, active participation and interaction, offering multiple possibilities for developing technical, contextual and behavioural competences.

As a first conclusion drawn from the experience, a learning-centered process requires that both teachers and students assume a more active role, greater shared commitment, and in the particular case of the students, greater responsibility for their own learning. Throughout the different phases the scientific basis of project-based learning is maintained to generate learning processes in which students are not passive recipients of knowledge, but are immersed in a pre-professional experience thanks to the link between the university and the regional administration, defining projects with real content, which require students to integrate the knowledge they have already gained from other courses with new knowledge attained in developing the project.

Personal competences are also developed. Students learn to work in teams, potentiating their personality and taking them closer to reality. The methodology arouses a spirit of investigation and innovation, creativity for the generation of new knowledge, productive thought, and motivation to learn and solve problems.

The operational instrument for the realization of this methodology has been agreements between the university and the regional administration, in which projects are accorded annually. Table 3 presents the topics of the 115 projects carried out by a total of nearly 900 students. These results show the potential of external agents—clients—in improving university teaching models, opening up new spaces for educational innovation with cooperative learning models based on projects.

A second conclusion would be that the necessary competences approach advocated by EHEA has been used as an opportunity to establish a new connection with the professional world by adopting the professional standard recognized internationally as our referent. The fundamentals of the project management competences defined by the International Project Management Association (IPMA) are adapted to facilitate training in technical, personal and contextual competences. This connection also permits linking university education with a system of professional certification, which opens up better future opportunities for our graduates.

As a final conclusion, we can highlight the qualitative leap that accompanies the change from methodologies based on the individual work of the professor to those based on more complex structures. In this sense, the relationship with the research group GESPLAN and the group of educational innovation GIE-project integrates teaching and applied research and develops an entire educational strategy for undergraduate and graduate programmes through project-based learning and project management competences as methodological approaches, together with the support of Information and Communication Technologies (ICT).

References

- AEIPRO-IPMA (2006) *Bases para la competencia en dirección de proyectos versión 3.0*. Valencia, Universidad Politécnica de Valencia.
- Allegre, C., Berlinguer L., Blackstone, T. & Rüttgers, J. (1998) *Sorbonne joint declaration: joint declaration on harmonisation of the architecture of the European higher education system*. Available online at: http://www.bologna-berlin2003.de/pdf/Sorbonne_declaration.pdf (accessed 25 July 2009).
- Bartkus, K. R. (2001) Skills and cooperative education: a conceptual framework, *Journal of Cooperative Education*, 36(1), 17- 24.
- Berlin Communiqué (2003) *Realising the European Higher Education Area. Communiqué of the Conference of Ministers responsible for Higher Education in Berlin on 19 September 2003*. Available online at: <http://www.bologna-berlin2003.de/pdf/Communique1.pdf> (accessed 15 June 2009).
- Bologna Declaration (1999). The Bologna Declaration of 19 June 1999. Joint declaration of the European Ministers of Education. Available online at: http://www.bologna-bergen2005.no/Docs/00-Main_doc/990719BOLOGNA_DECLARATION.PDF (accessed 1 October 2009).

- Cazorla, A. & De los Ríos, I. (1996) La enseñanza del desarrollo rural y la planificación en su nueva dimensión: una estrategia metodológica. Paper presented at the *II Jornadas Nacionales de Innovación en las Enseñanzas de las Ingenierías*, December 3, in Madrid, Spain.
- Cazorla, A. & De los Ríos, I. (1998) *La enseñanza del desarrollo rural: una estrategia metodológica. El Ingeniero Agrónomo en el contexto de la nueva Política de Desarrollo Rural*. Colección Jornadas Agronomía. Madrid, Fundación Premio ARCE.
- Cazorla, A., De los Ríos, I. & Ortíz, I. (2007) Una estrategia educativa de cooperación orientada a validar la competencia de los individuos en dirección de proyectos. Paper presented at the *I Jornadas Internacionales UPM sobre Innovación Educativa y Convergencia Europea (INECE '07)*, December 11–13, in Madrid, Spain.
- Cazorla, A., Marco, J.L. & De los Ríos, I. (1990) *El ciclo de los proyectos y la docencia: aplicación a una comarca rural*. Paper presented at the VI Nacional Conference on Project Engineering, June 26–29, in Almagro, Ciudad Real, Spain.
- Chinnowsky, P., Brown, H., Szajnman, A. & Realph, A. (2006) Developing knowledge landscapes through project-based learning, *Journal of Professional Issues in Engineering Education and Practice*, 132(2), 118-125.
- Commission of the European Communities (2000) *A memorandum on lifelong learning*. Available online at: <http://www.bologna-berlin2003.de/pdf/MemorandumEng.pdf> (accessed 15 June 2009).
- Commission of the European Communities (2001) *Making a European area of lifelong learning a reality*. Available online at: <http://www.bologna-berlin2003.de/pdf/MitteilungEng.pdf> (accessed 15 June 2009).
- Commission of the European Communities (2003) *The role of the universities in the Europe of knowledge*. Available online at: <http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2003:0058:FIN:EN:PDF> (accessed 15 June 2009).
- Convención de Instituciones Europeas de Enseñanza Superior (2001) *Perfilando el Espacio Europeo de la Enseñanza Superior*. Available online at: <http://www.educacion.es/dctm/boloniaees/documentos/02que/salamanca.pdf?documentId=0901e72b8004aa8b> (accessed 1 October 2009).
- De los Ríos, I., Dorrego, A., Cazorla, A. & Ortiz, I. (2006) Project management and scientific cooperation networks: the innovation as social learning model in Puno mountain region. Paper presented at the *10th International Conference on Project Engineering*, September 13-15, in Valencia, Spain.
- Delcourt, J. (1999) Nuevas presiones a favor de la formación en la empresa, *Revista Europea de la Formación Profesional*, 17, 3-14.
- Echeverría, B. (2002) Gestión de la competencia de acción profesional, *Revista de Investigación Educativa*, 20(1), 7-43.
- European Council (2000) *Lisbon European Council (23–24 March 2000). Presidency Conclusions*. Available online at: http://www.europarl.europa.eu/summits/lis1_en.htm (accessed 15 June 2009).
- Gijsselaers, W. H. (1996) Connecting problem-based learning with educational theory, in: L. Wilkerson & W. H. Gijsselaers (Eds) *Bringing problem-based learning to higher education: theory and practice*. San Francisco, CA, Jossey-Bass, 13-21.
- Grootings, P. (1994) De la cualificación a la competencia: ¿de qué se habla?, *Revista Europea de Formación Profesional*, 1, 5-7.
- Hackett, R.K., Martin, G.R. & Rosselli, D.P. (1998) Factors Related to Performance Ratings of Engineering Students in Cooperative Education Placements, *Journal of Engineering Education*, 87(4), 445-458.
- Johnson, P.A. (1999) Project-based, cooperative learning in the engineering classroom, *Journal of Professional Issues in Engineering Education and Practice*, 125 (1), 8-11.
- Kelly, W. (2007) Certification and Accreditation in Civil Engineering, *Journal of Professional Issues in Engineering Education and Practice*, 133(3), 181-187.
- Merrill, M. D. (2002) First principles of instruction, *Educational Technology Research and Development*, 50(3), 43-59.
- Ministerio de Educación y Ciencia (1985) *Estudio sobre la calidad de la formación universitaria*. Madrid, Ministerio de Educación y Ciencia.
- Mulcahy, D. (2000) Turning the contradictions of competence: competence-based training and the beyond, *Journal of Vocational Education and Training*, 52(2), 259-280.
- Nickerson, R. S., Perkins, D. N. & Smith, E. E. (1985) *The teaching of the thinking*. Nueva Jersey, Lawrence Erlbaum Associates.
- Padmanadhan, G. & Katti, D. (2002) Using community-based projects in civil engineering capstone courses, *Journal of Professional Issues in Engineering Education and Practice*, 125(1), 12-18.
- Parsons, C., Caylor, E. & Simmons, H. (2005) Cooperative Education Work Assignments The role of Organizational and Individual Factors in Enhancing ABET Competencies and Cp-op Workplace Well-Being, *Journal of Engineering Education*, 94(3), 309-316.
- Sáenz de Miera, A. (1997) Después de la Universidad ¿qué? *Newspaper ABC*, October 5.
- Sánchez Nuñez, J.A. (1996) *Los métodos de enseñanza. Curso superior de formación para la docencia universitaria*. Madrid, Instituto de Ciencias de la Educación (ICE), Universidad Politécnica de Madrid.
- Schmehr, W. & Knoepfel, H. (Eds) (2008) *International Project Management Association certification yearbook*. Available online at: <http://www.aepro.com/files/AEIPro/boletines/R13CertYB2008h.pdf> (accessed 15 September 2009).

ⁱ Royal Decree, 26 June 2007, by which planning of official university education in Spain is established.

ⁱⁱ The International Project Management Association (IPMA) is a non-profit organisation, whose function is to be the prime promoter of project, programme and portfolio management (PM) internationally. IPMA started in 1965, under its former name of INTERNET, as a forum for the exchange of experience amongst project managers of international projects. It hosted its first international conference in 1967 in Vienna, and since that time has developed steadily, as indeed has the discipline of project management itself. On June 14, 1998 in Ljubljana, Slovenia, the IPMA Council confirmed the establishment of IPMA's universal four level system which was approved on February 28, 1998. The certification in project, programme and portfolio management was then realised by the certification bodies of the Member Associations.

ⁱⁱⁱ The ICB Version 3.0 (2006) consists of 46 competence elements: 20 technical competence elements dealing with the project management matter on which the professionals are working; 15 behavioural competence elements dealing with the personal relationships between the individuals and groups managed in the projects, programmes and portfolios; 11 contextual competence elements dealing with the interaction of the project management with the context of the project and within the permanent organisations elements.