Implementing new learning methodologies in the Hard Sciences

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Abstract— **Today's society is undergoing constant changes and this is reflected in the way the working world is structured. There is an increasing need of qualified professionals having to face changes and prove effective competencies dealing with the Information and Communication Technologies (ICTs).**
In this sense, the 21st Century university should offer students the suitable learning tools to become successful professionals. With this goal in mind the Tunning Project aims at implementing active methodologies by enhancing content learning and competencies acquisition.
In this paper, we include a comparative study of the efficiency of new learning methodologies across subjects, degrees and academic cycles and focus on the role of the ICTs in the learning process. Our objective is to assess the suitability of these new methodologies for technical subjects. Finally, we present a survey on professors' willingness to implement active methodologies.

Keywords-New learning methodologies implementation, continuous evaluation, students' satisfaction, competences and quality.

I. INTRODUCTION

Nowadays changes in society are being reflected in the working world. Likewise, the education area should be undergoing such dynamic pattern. Our globalized world demands really high qualified professionals able to face challenges and, at the same time, master key competencies and prove efficient skills in ICTs [1,2]. As a matter of fact, our 21 st Century University should train students to become autonomous learners and citizens able to cope wi th a constant changing working world.

Among other challenges, university students have to deal with a huge amount of knowledge just generated in the last few years [3], in this sense, their training should aim at enhancing self-learning ("learning to lear n") besides from acquiring core contents, which will eventually become obsolete [4].

Therefore, universities should change their focus onto a more competencies -based view providing, then, future professionals with abilities [5, 6, 7] and habits that allow them to keep on learning throughout their professional careers. Definitely, ICTs can help achieving this lifelong learning goal as many recent studies have shown, among others, [1,2], within the Engineering field.

On the other hand, self-learning [4] is one of the most valued skills to succeed professionally.

In order to reach such an autonomous learni ng and master specific and inter disciplinary competencies (following the Tunning Project [8]) it is necessary to implement active methodologies in the subje cts as through these new tools both professors and students can work on the subjects contents and competencies simultaneously. Not to mention, the key role ICTs play in this recent learning process model.

In this sense, the Polytechnic European Universit y of Madrid and the Polytechnic University of Catalonia (EISEIAT) among others, are changing the scope of several University studies, such as Environmental Sciences or Telecom and Industrial Engineering to suit the European Higher Education Area (EHEA). As to the curricula, we have to mention that the learning is always student -oriented and based on the competencies this profile of students should have after graduating. With this goal in mind, we have incorporated new teaching methodologies and the use of I CTs in our classrooms and labs. Precisely, some of the methodologies used are related to the Cooperative Learning (CL) [9, 10, 11, 12] and Problem/Project Based Learning (PBL) [13, 14, 15, 16, 17, 18, 19]. These two methodological approaches to both teachi ng and learning allow students to become responsible for their own learning, decision making and knowledge developing starting from their professors' guidance, activities planning and new learning scenarios.

So as to apply such methodologies a professor m ust reflect on the specific learning objectives and the selection or design of problems and/or activities by first ly identify the learning needs of these students in particular. Besides, this professor should be aware of all the subjects taught in the same degree and, therefore, coordinate with the other professors involved. [20]. We would like to emphasize that during the whole process professors should design a follow -up plan of their students' work and, at the same time, an individual and team assessment. [17, 18].

The work presented in this paper is, therefore, a comparative

978-1-4244-6571-2/10/$26.00 ©2010 IEEE April 14-16, 2010, Madrid, SPAIN
IEEE EDUCON Education Engineering 2010 – The Future of Global Learning Engineering Education

study of the efficiency of active learning (AL) methodologies implementation in a wide range of subjects from different degrees and cycles at University. Not to mention, in this article we also focus on the use of the ICTs as a key tool in the learning process.

With this study, we aim at assessing and validating these new methodologies and tools in terms of suitability for technical subjects with such varied contents as the ones chosen for this research. Among others, we selected subjects from Environmental Sciences, Telecom and Industrial Engineering from the European University of Madrid (UEM) and the Polytechnic University of Catalonia (UPC). Besides, we have also focused on the possible differences in efficiency of those methodologies depending on the university cycle the particular subjects belong to. [1, 6, 7, 14].

Finally, we include a preliminary study on professors' knowledge on new methodologies and an example of AL methodologies implementation in a university subject with a small group of students from the UPC.

II. OBJECTIVES

Being aware of the multiple variables to account for in these typology of studies, we will precise the ones taken into account at each stage. In the first part of this paper we will describe our experimentation at the Superior Technical School (ESP) of the UEM.

First, we will assess the implementation of an AL methodology (Cooperative Learning and/or Problem/Project Based Learning) in three subjects of the first academic year in the Environmental Sciences, Telecom and Industrial Engineering degrees. Secondly, we will focus on the differences in acceptance of these methodologies across cycles and degrees within the same Technical School.

Aiming at the assessment of these new methodologies in terms of contributing to the learning quality and, more precisely, in the preliminary experimentation carried out in the selected subjects and cycles we have carefully taken into account the following points:

1. The evolution of the marks obtained by students: by comparing the percentage of grades resulting from the AL methodology implementation in the subject with the results from previous academic years when a more traditional learning approach was taken. In addition, the comparison of students' results between subjects where active learning techniques are applied and those where not both across degrees and cycles. We should emphasize here that only the subjects taught by the same professor during different academic years and using varied methodologies have been considered.

2. The results obtained from the student's satisfaction surveys dealing with the implemented methodology and the assessment of the competencies enhancement.

3. The results from the student's questionnaires on their satisfaction with the teaching staff.

Moreover, throughout the different sections of this paper we will comment on several studies carried out by other universities and whose results are very similar to ours, therefore, validating our work on the implementation of new learning methodologies in the hard sciences [6, 7, 14, 21].

Finally, we will include some professors' assessment on knowledge development and their application views on new methodologies of teaching and/or learning as well as a detailed description of the activities used during the implementation of such tools in our study.

III. DESCRIPTION OF THE ACTIVITIES USED

So as to design a wide range of activities to apply in each and every one of the subjects in this study we developed a common grid [22]. In it we have included examples of the key points to be considered when designing CL or PBL activities. In [22, 9, 16, 17, 18], a careful description of some of the activities carried out in the different subjects (scope of this study) is provided as well as other activities applied in similar studies taking place in other universities. Each activity aims at enhancing a particular competence, as it would be the case of team work (typically used in CL or PBL), oral communication or planning

Some of the activities that we can find in the above mentioned articles are the following:

1.- Project management and planning learning. A team work of maximum 10 students guided by a professor [20]. MS Project is used in here as a tool to plan and follow-up a project. Moreover, the professor will be handed in a weekly progress report on the specific project. Possible modifications from the original plan will be discussed and analyzed. On the other hand, the final project will be presented in video format (which should last no more than 10 minutes) and will be posted in Youtube (http://www.youtube.com/watch?v=NuIM_Ne5pvM) [23].

In addition, students will have to hand in written reports both from the initial project and the final one. These written exercises together with the video will be peer-assessed and defended in front of a jury formed by 3 professors from the Projects Department.

2.- Activity in English

2.1.- This 2h activity consists in explaining how to plan and conduct an oral presentation in English (theory) and practicing it later on. The professor spends between 30 minutes to an hour explaining how to present orally in this foreign language: organization of contents, use of sequencers and discourse markers, description of figures in pie charts, bar graphs, etc.) Not to mention, students are given all the vocabulary required to perform their presentation in English and, moreover, they also work on a divulging research paper from their studies

specialization. After, students prepare their own presentation on the article during 30 minutes in the computer lab. Finally, their presentation is assessed by both their classmates and the two professors involved in the acti vity (an English teache r and a professor from their specialty).

2.2.-Development of Portfolios or Wikis in English from one to a group of subjects [24,25].

3.- Creating Jigsaws and/ or crosswords using the specific vocabulary used in each particular subject and online questionnaires (Using Moodle for example). They could be learning exercises or follow -up activities before an exam to revise core content. These and other activities carried out in our study can benefit from the use of a platform where students can participate in a discussion forum and/or an exchange materials and store different contents. In the UPC we mainly used the Basic Support for Collaborative Work BSCW [2, 17,18] from the Engineering projects Department server.

IV. RESULTS

A. Comparing percentage marks of first year subjects.

In this initial part of the study we compared three subjects of the first academic year in the three different degrees.

Therefore, in this section we present the percentage of marks obtained in the three subjects when AL methodologies were introduced and compare the results with the marks from previous academic years when such methodologies had not been implemented in the classroom. As we have mentioned before, we only considered those subjects taught by the same professor in different academ ic years and using different teaching/learning methodologies.

In Table 1 it is shown the percentage of marks obtained by students from academic years 2004 /2005 and 2005/2006, in which CL activities were introduced in a subject from the Environmental Sciences degree and comparing such percentages with the ones resulting from previous academic years when a more traditional methodology (based on the lecturing method) was used.

TABLE I. PERCENTAGE OF THE MARKS OBTAINED IN THE SUBJECT THROUGHOUT SEVERAL ACADEMIC YEARS.

n=nº students	Percentage of marks according to the total number of students (%)				
	AB	F	P	VG	EX
A. Year 01/02 (n=45)	4	40	41	13	2
A. Year 02/03 (n=29)	3	37	40	13	7
A. Year 03/04 (n=17)	19	33	33	15	0
A. Year 04/05 (n=16)	31	30	19	13	7
A. Year 05/06 (n=20)	10	21	25	23	21

This traditional methodology was based on professors' lectures and was complemented with practical exercises to reinforce the contents given in class. In those academic years the percentage of passing marks were of 56%, 60%, 48% respectively and it is during the academic year 2004/2005 when CL methodology is firstly introduced in this subject and activities are designed to cover approximately 30% of its syllabus. To this respect, we can observe that the total percentage of passing marks is 39%, which compared to the results from previous academic years is a considerable drop. We could explain this figure by taking into account that there seems to be an increase in Non Presented students AB (31%) as the percentage of passing marks compared to the total number of presented students is 67%. (From now on we will use the following abbreviations: AB as "Absent ", F as "Fail", P for "Pass", VG "Very good" and EX for "Excellent").

On the other hand, during the academic year 05/06 the amount of l ectures is reduced to 20 % of the syllabus and the rest of the core contents are worked through CL activities. We can see that this year the p ercentage of students increases significantly (69%) and the number of a bsenteeism is reduced when comparing with the percentages of the two previous academic years. At the same time, there also exists a significan increase in the percentage of VG and EX making the same comparison. Therefore, we could say that the more implementation there is of AL methodologies, the more familiar students become with them and this fact could explain the better results they obtain in academic years 04/05.

1) A. Comments:

The several changes made throughout the two academic years when AL methodologies were implemented together with the increasing experience of the professors involved in such challenge could imply that students may improve their results when most of the s yllabus is taught through an AL approach. We could also relate this success to the increasing number of subjects including AL methodologies during the second academic year within the Institution and, hence, to the greater familiarity of students with these new teaching and learning tools.

As a matter of facts students need to know about each institution's culture towards the use of new methodologies in the learning process. As we can see in the available literature on this topic such requirement also appear s in other pilot studies, as in [9][12][13][17] , which are examples mainly taking place at university level.

Another aspect to highlight from the results obtained in our study is the increase of VG and EX marks if compared with students' grades from prev ious academic years. It seems, then,

that these active methodologies enhance and guarantee a greater learning of the students who join and involve themselves in the dynamics of the subject. Moreover, this sample of students (n) find AL activities more motivating than the traditional ones and this fact, in return, is reflected in their academic results. [17].

1st year subject in Telecom Engineering, specific branch of Sound and Vision. This is a practical subject which underwent the European Credit Transfer System (ECTS) adaptation during the academic year 05/06, which decreased the number of lecturing sessions to 20% and organized the rest of the tuition using CL activities.

According to our results it seems that the introduction of this methodology increases the percentage of AB and F students if compared to an academic year where traditional methodology was in use (15%). At first, we could think that some students may be reluctant to get involved into such new methodological approaches and so drop out the courses. However, as previously seen in the Environmental Sciences subject, results show an obvious increase in the total number of students obtaining the highest marks possible (VG and EX) in the academic year 2005/06 moving from 42% to 63%.

In previous studies [22], it has been shown that the implementation of these methodologies in practical subjects' results in raising the number of VG and EX but, at the same time, the amount of AB and F, therefore validating the results obtained in the present study.

At this point, we should reflect and consider the existence of other possible factors which could affect students' behavior. This would be the case of the degree of maturity of each individual, the familiarity of the student with AL approaches in other subjects or contrary to it, the lack of knowledge and/or practice of such learning tools or the low interest of students in them.

In the 1st year subject of the Industrial Engineering degree during the academic year 05/06 the number of tuition using the lecturing method is reduced to 40% and the remaining 60% is carried out by developing CL activities. And again, our results clearly repeat the trend identified in the preceding sections.

This fact shows that although some students do not get involved when using this active methodology, the ones who do increase their interest and motivation toward the subject in particular and they finally learn more and obtain higher marks.

B. Survey results on the satisfaction of students towards the implemented methodology.

The assessment on the introduction of the methodology has been carried out taking into account the students' view, obtained by filling an anonymous questionnaire on their satisfaction with the CL methodology at the end of the course. A complete sample of the survey is included in the following paper [22].

In this study, we have calculated the percentage of students who "agree" or "very much agree" with each question in the survey. A unique percentage is shown when no significant differences are found between the three subjects studied, in which case the percentage equals the total sample analysed.

One of the most relevant points is the section which deals with questions related to the learning process. In this part we can point out the following results:

91% of the students claim that they have learnt and understood the contents of the course.

63% of the Telecom and Industrial Engineering students think that the introduction of this new methodology has increased their interest in the subject while only 30% of the Environmental Sciences students agree with the methodology used.

As to competencies enhancement, 48% of the students agree with the claim that these activities have improved their oral skills and 40% consider them a key factor in the development of their written abilities. However, it is significant that although all the activities had been designed and planned to reinforce both competencies more than 50% of the students disagree. These results could be argued if we consider that a semester is insufficient time for students to perceive any progress in the development of their oral and written skills and, hence, they should keep working on such competencies in the following academic years.

70% of the students claim that this methodology helps developing their capacity to synthesize and understand information which, in fact, is one of the main targeted competencies in the EHEA.

85% of the Telecom and Industrial Engineering students think that this AL methodology has enhanced both team work and debate of information, as it is also observed in a similar study in this field [15].

In addition, 68% of the students in the sample consider this methodology as a key factor in increasing their ability in planning and time management. In fact, the activities were designed taking into account that such competencies are crucial for first year students and, therefore, should be emphasized and our results show that the implementation of AL methodologies in the hard sciences succeeded in this sense.

The following matter to be tackled was planning, and in here we would like to point out that 75% of the students in our survey found that their professor's objectives totally coincided with what was taught in the classroom.

However, we could observe varied opinions when students from different academic backgrounds assessed the preparation of the materials delivered by the professor in each subject. (See Telecom and Industrial Engineering 74% and Environmental Sciences 57% respectively).

Another relevant piece of information is drawn by the figures we obtained concerning team work sessions as 100% of Telecom Engineering students, 78% of Industrial Engineering and 43% of Environmental Sciences claim that those sessions were very useful and well-organized.

Besides from the data collected in the students'

questionnaires, most of them think that the activities designed targeting AL methodologies implementation meant a greater workload and a consequent lack of time to carry them out. Thereby, professors should think about restructuring activities timing for the following academic years.

In the case of the subject taught in the Environmental Sciences degree, the professor has been incorporating this type of methodology steadily and confirms that teachers need a learning period to design the activities carefully and implement them properly in the class. This opinion is common to all the authors who consider that these kind of methodologies should be implemented in the subjects gradually with an improving period for the activities chosen of approximately 3 academic years [12, 26,27].

As to the results concerning assessment, 65% of the students in the 3 different degrees claim that team work evaluation has been fair and has helped improving the learning process throughout the whole year.

C. Students' performance according to degree and cycle

Once the study presented here was finished and we had carefully considered its results, another question came into our minds: whether these AL methodologies were equally considered across the different academic cycle or significant differences would appear. Through such results we would be able to verify and, after, validate behavior patterns within the same degree and also check for any repetition pattern occurring in each degree or cycle.

With this goal in mind we selected subjects from the first and second cycles in several degrees. The resulting figures were compared to subjects (within the same cycle) which did not incorporate any AL methodology in the classroom.

After introducing these new methodologies in the degree of Environmental Sciences we could observe a significant decrease of P (28 %) corroborating, then, the results initially obtained when only considering first year subjects and finding exactly the same patterns in the degree.

On the other hand, in the first cycle of the Telecom Engineering degree there seems to be a clear increase in the percentage of passing marks (P) when using AL methodologies. At this point, we would like to emphasize that the higher number of students' marks belong to the categories of (P) and (VG) and there is a decrease of students obtaining (F).

Finally, in Industrial Engineering first cycle we have also detected an increase in the percentages of (P) and (VG) with the implementation of such methodologies but the improvement in student's marks is even greater during the second cycle.

Hence, we could conclude that in Telecom and Industrial Engineering the introduction of LA methodologies generally improves the performance of students in the two different cycles.

D. Professors' Global Evaluation

So as to know the degree of influence of the introduction of AL methodologies in students' assessment of their professors' performance, we have analysed the results of university questionnaires on students' satisfaction taking into account and, thus, comparing the subjects following a Cooperative Learning (CL) approach and the ones with a more traditional learning approach in those surveys where students showed a lesser agreement with CL, that is to say, Environmental Sciences and Industrial Engineering.

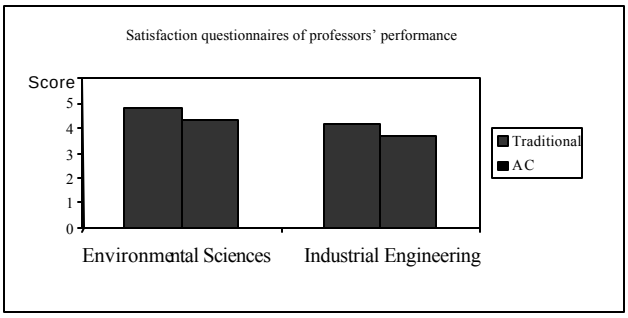

Figure 1. Student's results on satisfaction questionnaires of professors' performance.

According to the results shown in Figure 1 there are no significant differences in the global assessment given to professors regardless of the learning methodology used and the satisfaction of the students with it.

Focusing on each degree analysed, we could see that there is a slight change in Telecom Engineering results and there is a significant increase in the case of Industrial Engineering.

Among the several experiences carried out in the Polytechnic University of Catalonia (UPC), it is precisely in the Technical School of Castelldefels where a pilot plan for new learning methodologies in the classroom was implemented and where, in addition, specialized professors provided staff from the same university or others in Spain with the suitable teachers' training (later on). [28].

We could say that there is a set of key factors that could improve professor's assessment by students, among others, student's familiarity with the new methodologies used in the classroom and the proficiency and skill of professors in their application.

So as to assess the latter factor (professors self-assurance) a set of questions was developed after a School's Symposium in the EPSEVG Centre (UPC) [29][30]. Our aim was to find out which methodologies were familiar to the professors attending the event and which ones were applied or were to be implemented soon. Not to mention, grading their precise level of self-confidence during the process.

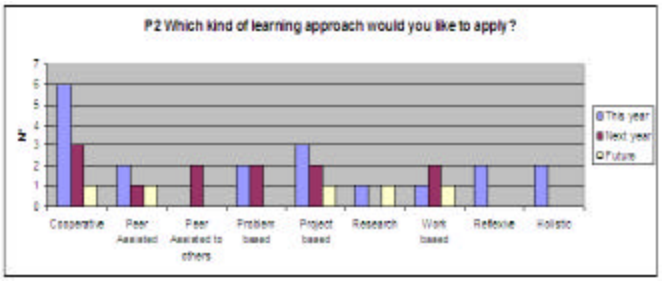

Figure 2. Professors' answers on their knowledge of methodologies, their application and future plans of implementation.

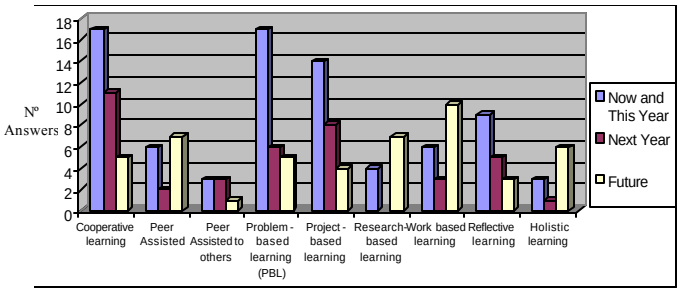

Figure 3. Professors' answers on their knowledge of methodologies, their application and future plans of implementation.

In 2008, we passed again the same test to several teachers from different Engineering Schools in Spain and France. Figures 2 and 3 show that the CL method was the most used during recent academic years but in Figure 3 we can see that two new methods have been used in the same proportion as CL: Problem Based learning and Project Based learning (this fact was shown by other studies). Moreover, we can also observe that some professors plan to use the Work Based Learning (WBL) methodology in the near future. In conclusion, our study can confirm that university teachers use new learning methods increasingly in order to be totally integrated in the EHEA in 2010.

V. CONCLUSION

The results presented in this paper show that the implementation of CL and PBL methodologies in first year subjects of three hard sciences degrees is positive. In addition, when comparing our results with the ones obtained by GREIDI (GRupo de Estudio en Innovación Docente en Ingeniería Universidad de Valladolid) group in academic years 2005 -2006 [2], we can see that the trends totally coincide, hence, validating our findings. In this sense, university students learn core concepts from each subject as well as enhance their oral skills, teamwork ability, planning competence and even leadership. Not to mention, their capacity of synthesizing and understanding the information given in each activity (especially designed by the professor for each subject in particular). We could say that all these elements will contribute to make students ready for the following subjects in their curriculum and to develop the competencies required in their professional career. [31, 2].

On the other hand, ICTs play a key role in the "newly" designed activities and constitute a solid platform or support for the subject's planning, material sharing and management by both students and professors. Therefore, our first conclusion would suggest that CL and PBL implementation is positive and suitable for the different technical subjects selected in this study, regardless of their contents.

Furthermore, this work shows that students are required a greater effort when using these AL methodologies but the more involved in them, the better results students obtain.

In the latter study concerning the comparison of results in terms of acceptance of AL methodologies implementation in different cycles and degrees, we can generally confirm students' higher performance but, at the same time, possibly because of their lack of awareness of their expected higher degree of involvement in such type of methodologies, there may exist some confusion among students and, hence, the is no acceptance patterns when considering academic cycles. Finally, we have observed professors greater self-assurance and experience in new methodologies implementation, which will, in turn, help students acquire more knowledge, training and confidence in its application in the classroom.

REFERENCES

[1] Fandos, M.y González Soto, A.(2006). "Estrategias de Aprendizaje ante las Nuevas Posibilidades Educativas de las TIC".[pdf].España. URL: http//www.u.h.cu/static/documents/STA/Estrategias%20aprendizaje%20TIC.pdfGrupo

[2] Greidi. Universidad de Valladolid "GREIDI: Profundización en la aplicación de experiencias de aprendizaje activo en el ámbito de la ingeniería", IIJornadas UVaEEES 2006. URL: http://www.greidi.uva.es/articulos/IIJornadas_UVaEEES_2006.pdf

[3] Johnson, D.W., Johnson, R.T., Holubec, E.J. "El Aprendizaje Cooperativo En El Aula". Buenos Aires: Paidós (1994).

[4] Carrió, M. y Aris, A."Diseño de recursos multimedia de biología para un aprendizaje autónomo basado en problemas". Congreso uab 2005.

[5] Cepeda Dovala J. M. "Metodología de la enseñanza basada en competencias" Revista Iberoamericana de Educación (ISSN: 1681-5653) 2005.

[6] Posada Álvarez, R. "Formación superior basada en competencias interdisciplinariedad y trabajo autónomo del estudiante" Revista Iberoamericana de Educación ISSN: 1681-5653 (2003)

[7] Tejada Fernández,J. y Navío Gámez, A. " El desarrollo y la gestión de competencias profesionales: una mirada desde la formación" Revista Iberoamericana de Educación (ISSN: 1681-5653); número 37/2; 2005.

[8] González, J. and Wagenaar, R. "Tuning educational structures in Europe. Informe final fase 1". (Eds.) Bilbao: Universidad de Deusto (2003).

[9] Sánchez Robert, F.J. Casanella Alonso, R. Fernández Vargas, I. "Introducción sistemática del aprendizaje cooperativo en la asignatura electrónica digital de la EPSC".

[10] Ovejero, A. "El aprendizaje cooperativo: una alternativa eficaz a la enseñanza tradicional.": Barcelona: Promociones y Publicaciones Universitarias (1990).

[11] Cuseo, J.B. “Cooperating Learning: A Pedagogy For Addressing Contemporary Challange s And Critical Issues In Higher Eduaction”. New Forum Press, 1996

[12] Lara, S. “Una Estrategia Eficaz Para Fomentar La Cooperación”. 99 Ese: 1. (2001).

[13] Barà J. “Aprendizaje Basado en Problemas/proyectos: ¿Qué, porqué cómo?” Institut de Ciències de l’Educació, Julio (2003).

[14] Sanz Angulo, P.;Benito Martín, J.J.; Araúzo Araúzo, J.A.; Del Olmo Martinez, R. “Utilización el autoaprendizaje basado en métodos cooperativos para la enseñanza del marketing en carreras de ingeniería.” X Congreso de Ingeniería de Organizació n. Valencia (2006)

[15] Giorgis N. y Cardona S. “Experiencias exitosas en las aulas de Ingeniería.” Boletín Electrónico Nº 2. (2004).

[16] Martí, E. Julià, C. y Gil, D. “PBL en la docencia de Gráficos por computados. Una comparativa con la clase magistral” JAC 2007.

[17] Romero García, M.C. y Amante García, B. “Formación en competencias utilizando metodologías de Aprendizaje Cooperativo”. JAC 2007.

[18] Amante García B. and all “Diseño de actividades para la introducción del inglés en asignaturas técnicas”. III Jornadas de Inn ovación Universitaria, Jiu 2007.

[19] Angulo C., Ponsa P. y Raya C.”Construcción modular de robots móviles. Proyecto basado en portafolio para estudiantes de grado” IEEE - RITA vol1, noviembre 2006.

[20] P. Ponsa, B. Amante, J.A. Roman, S. Oliver, M. Díaz and J. Vive s, “Higher education challenges: introduction of active methodologies in Engineering curricula”. International Journal of Engineering Education, vol 25,(4), pp. 799 -813, 2009.

[21] Fernández Iglesias M. J., Rodríguez González F. y Medina Ferreiro E. “El Centro Multimedia de Galicia: un modelo de colaboración entre el sector público y el privado en el desarrollo de e -learning” IEEE-RITA vol2, Mayo 2007.

[22] Amante García B. and all ”Estudio comparativo de la metodología de aprendizaje cooperativo en dos escuelas técn icas“. III Jornadas de Innovación Universitaria, UEM (2006).

[23] Axel Anglada Galan, Fernando Blanco Romeu, Alex Lacayo Vidal, Rosa Murcia Comas, Marc Piqué Miserachs, Eva Raventós Ramon, Beatriz Amante García, Neus Fradera Tejedor. “Proposta de metodologia a seguir per la presa de decisions davant les diferents alternatives de millora en l’accessibilitat d’una estació” Tecnodiscat 2009.

[24] Jane Alexen Shuyska and Chris Davies "ThinkSpace: the collaborative process of designing new technologies for the classroom ", 2008 Wikisym 2008.

[25] Louis-Philippe Huberdeau, Sébastien Paquet, and Alain Désilets "The Cross-Lingual Wiki Engine: Enabling Collaboration Across Language Barriers", 2008 Wikisym 2008.

[26] Benito, A., Cruz, A. “Nuevas Claves Para La Docencia Universitaria En El Espacio Europea De Educación Superior”. Madrid: Narcea S.A. (2005).

[27] Proenza Garrido Y. Leyva Leyva L. M. “Reflexiones sobre la calidad del aprendizaje y de las competencias matemáticas”. Revista Iberoamericana de Educación (ISSN: 1681 -5653) n.º 40/6 – 15 de diciembre de 2006.

[28] Bará J. “¿Hemos de cambiar la manera de enseñar? ¿Cómo hemos de hacerlo?” 2006

[29] J. A. Roman, “Structure of the Engineering Degree curriculum in EPSEVG Center”, First Symposium on Higher Education at EPSEVG Center, in: http://www.epsevg.upc.edu/jd/programa. asp, (2006).

[30] J. A. Roman, “ Virtual Teaching Forum ”, EPSEVG Center, in http://www.epsevg.upc.edu/fdv/, (2007).

[31] Felder R. And Brent R. “Cooperative Learning In Technical Courses: Procedures, Pitfalls, And Payoffs”. Eric Document Reproduction Service Report Ed 377038 (1994).