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Intellectual Property Course for Engineering Students*

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The use of active learning methodologies is an issue of great concern for improving education quality. In this paper, the authors provide an innovative point of view for an Intellectual Property (IP) course. This course is designed by engineers for engineers. The course has been designed so that the students have to complete three different projects. The first project is centred on trademarks, the second one on patents and the third one is the extension of one patent to others countries, that is, the national stage of the patent. According to the results of the evaluation of the projects, most of the learning objectives have been achieved and the students have improved their skills, such as self-learning, creative thinking and troubleshooting. This paper describes the implementation of these different projects. These experiences can be easily replicated in other universities.

Keywords: active learning methodologies; engineering education; intellectual property

1. Introduction

This course was based on considering four different related motivations. The first one is related to the teachers' experiences as inventor engineers. Throughout all our education, none of us have received training on intellectual property. However, when working, we have developed several systems that we have had to protect. We had to use self-learning in order to obtain a Spanish patent [1–5], a European patent [5] and the national stage of the patent [5]. The second motivation is that we realized that the vast majority of the available courses are focused on law students or lawyers [6–8] and courses for engineer are quite unusual [9–11]. Moreover, the approach to intellectual property over most of these courses is through a large number of laws and procedures; this approach is very hard for engineering students. The third motivation is the necessity for the engineers that work with intellectual property in order to improve the patent quality is as described in [12]. The fourth one is related to what is explained in [13]:

> Many social, political, and ethical constraints in engineering design are directly related to IP, and IP-related issues that have a significant impact on a global economic and societal context. Therefore it is valuable for engineering students to consider the broader impacts of IP as well as the basic knowledge.

The foregoing statement is contained in the ABET criteria [14], in particular, ABET Criterion 3, outcome (c) requires the students to demonstrate:

> an ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability.

Additionally, outcome (h) requires the students to demonstrate:

> the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context.

In this course, the methodology proposed is project based learning. The teacher provides practical project experiences during the Intellectual Property course teaching process, because it is demonstrated that the effectiveness of a course can be increased through hands-on experiments, as was pointed out years ago [15]. Similar studies often appear in the literature emphasizing the importance of an experience environment for teaching [16–17]. Moreover, the teacher may also train the students in the other ABET criteria, which is a very scarce issue in the graduate formation.

According to the above explanation, this Intellectual Property course represents an innovation because it is designed with the experience of engineers and for engineers and it is conceived as an under-graduate engineering course and not as post-graduate law course. Moreover, this course includes training in different ABET criterion from a new point of view. This may be considered an important innovation compared with current courses on Intel-

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lectual Property, which are mainly aimed at lawyers and post-graduate students.

In addition, the e-Learning materials provided by the Spanish patent office [18] are used as a complement to this course and a good reference to support the preparation of the course, along with the material provided by the European Patent Academy [19]. The rest of the paper is organized as follows: Section 2 develops the three different subprojects concerning Intellectual Property, while Section 3 presents the learning methodology and the objectives of the course. Section 4 develops the course assessment. Finally Section 5 presents the conclusions.

2. Intellectual property course evolvement

The course is developed in the University of Extremadura as an elective course for all students on the Merida campus. This field is very suitable for engineering students and also the students who are pursuing a degree in industrial design. Although there are no prerequisites for the IP course, senior-level undergraduate students are required. The IP course is a 4.5 credit course and has been designed for students in their last academic year. In addition, part of this course is developed in the Master of Introduction of Research as part of a 6 credits signature. The course has been taught since the academic year 2011/2012. The teachers make available a forum for regular questions and all the materials related to the topics are available through a virtual Moodle classroom. In addition, the teachers provide a timetable to assist the students.

2.1 Project approach

The course was organized in three different subprojects: it is necessary to use the knowledge gained in subproject 1 to do subproject 2 and the knowledge acquired in subprojects 1 and 2 to make subproject 3. The initial two sessions of the course are devoted to an introduction to Intellectual Property. For each of the three subprojects that comprise the course, a theoretical section and a detailed instruction of the tasks to be done are provided, along with deliverables (slides of both parts are available online and a discussion forum is enabled in order to solve questions and concerns). The teachers also provide a timetable in which they are available to assist students. The projects are designed to be carried out individually. The students are required to deliver a report of their work for each project within pre-set dates.

2.1.1 Subproject 1

The subproject consists of adequately presenting the registration of a trademark. First, the teachers introduce the basic concepts about trademarks and patents. Moreover, they explain the Nice Classification and its use. Each student has to register the trademark in different classes according to the Nice Classification. In order to complete subproject 1, the students have to go to the website of the Spanish Office of Patents and Trademarks where they can find all the information necessary for registration of a trademark. Finally, they should be aware of the different systems of trademark search to make sure that their brands have not previously been recorded. The students are required to present the complete registration form of the trademark concerned.

2.1.2 Subproject 2

The subproject objective is to present the application for a patent, utility model or industrial design to the Spanish Patent and Trademark office. In order to facilitate the completion of the subproject, a student can invent any non-existing machine, although it may be unreal or unrealizable. For example, the teacher proposes to patent a teleportation machine. In the initial stage, the teachers introduce the concept of a patent, showing the conditions of patentability, that is, the teacher must teach the students how to distinguish between what is patentable and what is not patentable. In addition, the teachers have to explain the difference between a patent, an industrial design and a utility model. Finally, the teachers explain the different parts that the document of one patent must contain. They also have to point out the importance of the claims. In the next step, the students have to know the different public agencies that provide free help and advice on these issues. They will also have to learn for themselves what an acceptable report is. Finally, they should be aware of the different systems for patent search to make sure theirs inventions have not previously been patented. For example, a student presents the following patent, a web cam that can be used in all types of monitors, and two illustrations inside this patent document are included (showed in Fig. 1). The teacher must receive the complete registration of the concerned patent.

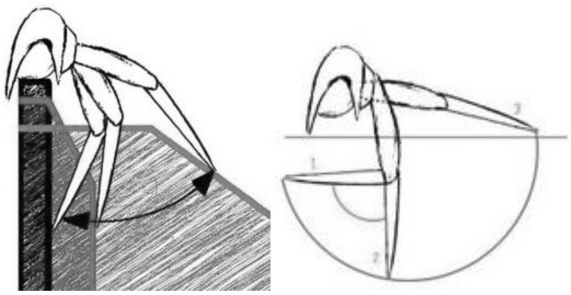

Fig. 1. Examples of illustration of a patent presented by one student.

2.1.3 Subproject 3

The project is focused on the extension of the patent or industrial design to different countries. Each student should choose a country in which they want to patent their invention. This is the hardest part for students because the contents in law aspects are greater. The students are required to present the completed registration form of the patent.

3. Learning methodology and objectives of the course

3.1 Learning methodology

The proposed learning methodology is organized in three different steps:

1. Initial stage. In this first stage the teachers have a prominent role: they should instil a great motivational attitude in their students. The teachers must introduce the theoretical concepts, making a presentation of the project to be solved by the students, which is the fulfilment of a patent application, and also facilitate the project planning. Then, the students learn and internalize the initial concepts and formulate the project.
2. Research and self-learning. The role of the teachers is to facilitate the implementation and development of effective resolution processes for the projects. The students need to learn how to get information when needed, since this is essential for the students to develop research skills. In addition, the students should take responsibility for their own learning. In this stage, the teachers try to develop the student capabilities, such as data analysis, self-learning, creative thinking, initiative, leadership and decision making.
3. Evaluation. The evaluation combines different parts. The projects are evaluated through the realization of reports that contain a complete patent/copyright document to apply for the patent. In addition, all students are forced to present a document describing their reports to the rest of their classmates. Thus, the classmates and the teachers act as if they were agents of the Spanish Office of Patents and Trademarks. Both an oral presentation from each student and a questions round of the rest of the students and the teachers are considered for the evaluation.

With this methodology the students develop the ethics and professionalism in two ways: first, they must be aware of the importance of Intellectual Property and the danger of plagiarism; second, the must be responsible of their questions and the scores assigned to their classmates. In addition, skills such as oral presentation and report preparation are developed.

3.2 Objectives

In this subsection we develop the educational objectives to be achieved with the completion of the three subprojects. The educational objectives are grouped into two categories: achieved knowledge and developed skills.

First the developed skills are described below:

Self-learning: the students must search in the web for the different requirements that exist in the different countries in order to extend his patent to one country.

Creative thinking: the students must patent one object that has not being patented before and, as a consequence, they require very creative thinking to achieve this.

Develop critical thinking: the students must evaluate their classmates patents and they must try to identify the problems in the inventions of their classmates.

Oral communication: they have to prepare three oral presentations, one for each subproject.

Report preparation: They have to prepare three reports, one for each subproject.

The learning outcomes (LOs) can be divided into three domains: cognitive, affective and psychomotor, according to Blooms taxonomy [20]. The learning outcomes proposed in this course are cognitive learning outcomes and overall psychomotor learn-

Table 1. Learning outcomes

	Learning outcomes (LOs)	
Exp. number	**Cognitive LOs**	**Psychomotor LOs**
1	Knowing basic principles of Intellectual Property Knowing how a trademark is registered	Hands-on doing a Trademark
2	Know that it is patentable Know what requirements must be fulfilled to present a patent Know the differences between a utility model and a patent. Know the process to patent an invention	Hands-on doing a Trademark Hands-on doing a patent
3	Know how to patent an invention in any country in the world	Hands-on doing an extension of a patent

ing outcomes. The learning outcomes and the projects are shown in Table 1.

4. Course assessment

This course was successfully carried out in the academic years 2011/2012 and 2012/2013 and is also running this academic year. This section presents the project assessment in two different ways: the first approach discusses the LOs achieved by the students, the second presents the students opinions.

4.1 Cognitive learning outcomes achieved

The results of the project can be summarized in the following points: first, all students completed the subprojects 1 and 2 and 75% of students reached subproject 3. That is, all students were able to fulfil a patent and a trademark, so all students acquired a basic knowledge in the efficient operation of the Spanish Office of Patents and Trademarks. It should be noticed that 20% of students made it to the national stage in over two countries. Also, the students acquire the skills necessary to find the corresponding legislation of each country to patent any invention in any country in the world. Therefore, this subproject served to develop their self-learning capabilities among others.

The cognitive learning outcomes are obtained through an exam. The results of the evaluation of the knowledge acquired through the final exam are provided in Table 2. These scores are higher that the scores obtained in preceding years with traditional methods. Owing to the great differences between the answers of different students in the different questions, a variance column is added.

From the results of the final exam, the authors can extract the following conclusions:

- The knowledge of the patent is constructed in a vertical way: without knowing the basic principles it is impossible to understand the national stage. For this reason, the higher scores occur in the first questions and the lower scores are in the last question.
- The national stage has the lower mean scores and the highest variance scores, this is because not all the students completed the third subproject and those who did not complete the third one had very low scores in these questions.

Table 2. Student scores in final exam

Question related with	Mean scores	Variance
Basic principles of trademark	8.1	0.5
Basic principles on the patentability	7.9	0.4
Utility model	6.8	1.1
Patent	6.7	1.1
Industrial design	6.8	1.2
National stage of patent	5.5	2.4

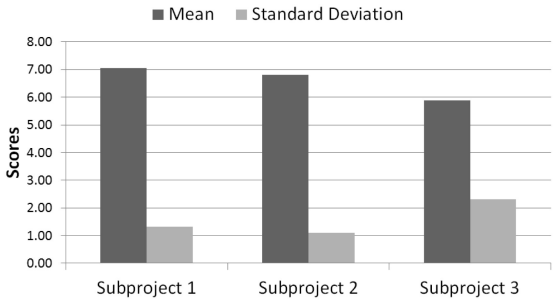

Fig. 2. Mean and standard deviation scores in the reports.

4.2 Psychomotor learning outcomes and skills achieved

The psychomotor learning outcomes have been evaluated through the report evaluation and the results can be observed in Fig. 2, which provides the mean and standard deviation scores in the reports.

The different skills have been evaluated through a rubric during the oral presentation of each student, except the skill of report preparation. In Fig. 3, the mean and the standard deviation of the scores obtained in the skills are shown. The outcomes of each skill are reported below.

4.2.1 Self-learning

This skill has only been evaluated in subproject number 3. The students have acquired this skill if they are capable of finishing this subproject. The scores in the rubric were:

1 point: project not finished.
3 points: the student finished project 3 for one country.
5 points: the student finished project 3 for more than one country.

4.2.2 Creative thinking

This skill has been evaluated in subproject number 2. The students have acquired this skill if they are

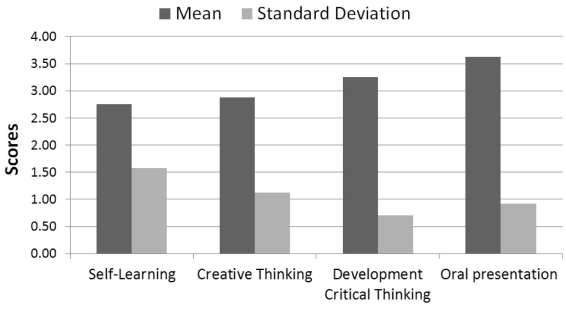

Fig. 3. Mean and standard deviation scores in the evaluation of the acquired skills.

capable to invent something. The scores in the rubrics were:

1 point: nothing invented or something that was already patented.
3 points: they invent something that it is impossible to fabricate, but has utility.
5 points: the students invent something with utility which is possible to be fabricated (for example the utility model of Fig. 1).

4.2.3 Development of critical thinking

They must analyse the problems in the invention of their classmates. For example, if the reports contain colour figures (as in the example in Fig. 1) and the colour figures are not allowed in patent/utility model application. They must evaluate their classmates.

4.2.3.1 Oral communication

They have to prepare three oral presentations, one for each subproject. They are evaluated through a complete questionnaire taking into account aspects such as: eye contact; voice; movement; fluency; . . . etc.

The results of the evaluation of the acquired skills lead to the following conclusions:

- The skill Oral presentation has the maximum scores. This is because this skill is also developed in other different courses during the itinerary needed to reach an engineer degree.
- The skill Self-learning has the lowest scores and the highest standard deviation because it is related to the subproject 3 completions.
- The skill Development of critical thinking has the lowest standard deviation because the vast majority of the students observed the same errors in the publications of their classmates, having similar scores as a consequence.

4.3 Students opinion of the course

This subsection provides the opinion of the students regarding the course expressed through an anonymous survey, at the end of the course. The survey shows the degree of satisfaction with the course and the developed projects: Table 3 shows the mean values for all students. The results of the survey include: 100% of the students rated the work on this course as very challenging, which motivated them to learn and they enjoyed more in the duration of the course than if they had dealt with the traditional methodology. Second, the students opinion is very good, with all items given a score above 4.

From the results of the survey, the following can be concluded. First, a good score in all items was achieved and, second, the students valued the experience and the methodology used more than the skill learned. Moreover, the support of the teachers during the project was evaluated very positively by the students. Finally, the limitations of this study are related to the inability of the student to communicate with the patent and trademark offices, thus the teacher has to act as patent and trademark officer. Another limitation, is the lack of student imagination to think of new developments that could be patentable.

Table 3. Students survey response (1 to 5)

The methodology for the proposed project: Strongly Disagree (1) / Strongly Agree (5)	**Mean**
Motivates me to learn	4.1
Encourages a better understanding	4.2
It helps me learn more about the subject	4.6
It helps me to correct misunderstandings	4.4
Improving my skills	4.1
It helps me relate the concepts of the subject to real-life situations	4.8
Enjoyed more than conventional classes	5
Learned more than standard classes	4.6

5. Conclusions

This paper provides a course to teach patents, which helps to expand the limited teaching literature in this topic. This methodology may be very useful for engineering students and the innovation of this course is the design of an Intellectual Property course in an eminently practical way, for an engineering profile and not for lawyers or similar. The results show that the main objectives of the projects have been achieved, i.e., the learning outcomes have been achieved reasonably well, the students have developed all subprojects with enthusiasm and motivation and they have developed important skills such as self-learning and creative thinking, which are education goals in higher education. In addition, the evaluation results demonstrate a high degree of compliance with curriculum goals. Finally, we believe that these learning experiences are quite encouraging, given the positive feedback obtained and the degree of satisfaction that was reflected in the surveys of the students. Other institutions wishing to establish a similar course can benefit from the experiences discussed in this paper.

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