STUDENTS FREQUENTLY ASK: 'YES BUT...WHAT IS THE *UTILITY* OF PHYSICS?'

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Abstract

Two Teaching Innovation Projects were carried out in the framework of the subjects 'Physics I' and 'Physics II' for different Degrees on Engineering at the Engineering High School of the University of Cadiz, Spain, during the 2013-2014 course. The aim of these Projects was to catch the interest of first-course students on physical phenomena and principles, a matter frequently considered as 'difficult' or even 'boring' for them when it is approached from an excessively formal scope. The methodology of the two Projects was based on experiments of Recreational Physics, different toys and devices, and other resources as posters, books and online contents. The Projects were conducted during Theory, Laboratory, and Online classes of Physics I and II, and their results were evaluated from questionnaires to the students. Main conclusions derived from them were: i) a significant increment on the interest of students on Physics and Science; ii) the aim of students for learning more about this kind of recreational physical experiments; and iii) a general sensation of enjoying the study and analysis of physical phenomena by students –and teachers as well–. In addition, students manifested their interest in this methodology to be applied to other Engineering subjects of their Degrees.

Keywords: Innovation, Teaching, Recreational Experiments, Physics.

1 INTRODUCTION

By definition, physical phenomena are ubiquitous in Nature, but their study could become tedious –or simply indifferent– for young students when it is approached in a solely abstract or formal way. In contrast, the study of principles and laws of Physics can develop all its attractiveness and interest when they are also shown from a more entertaining and closer scope. It was the aim of the Teaching Innovation Projects: **Students frequently ask: 'Yes but...what is the *utility* of Physics I?'** (*"¿Para qué sirve la Física I?" Preguntan los alumnos habitualmente* in Spanish, PI_14_016) and **Students frequently ask: 'Yes but...what is the *utility* of Physics II?'** (*"¿Para qué sirve la Física II?" Preguntan los alumnos habitualmente*, PI_14_017) in the framework of the subjects 'Physics I' (*Física I*; it includes Kinematics, Rigid Solid Dynamics, and Thermodynamics) and 'Physics II' (*Física II*; Force Fields, Wave Theory, and Electromagnetism), respectively, corresponding to the Degrees on Aerospace Engineering (DAE) (*Grado en Ingeniería Aeroespacial, GIA*), Industry Design and Product Development Engineering (DIDPDE) (*Grado en Ingeniería en Diseño Industrial y Desarrollo del Producto, GIDIDP*), and Technical Industry Engineering (DTIE) (*Grado en Ingeniería Técnica Industrial, GITI*), at the Engineering High School of the University of Cadiz, Spain (*Escuela Superior de Ingeniería de la Universidad de Cádiz, ESI-UCA*) during the 2013-2014 Course.

Despite the lack of funds to support the Spanish Universities in the last years [1], some procedures have been implemented within the Engineering courses to decrease academic failure [2,3,4]. In this context, the two Projects presented herein were carried out by using experiments of Recreational Physics, different toys and devices, and other resources as books and online contents, in order to catch the interest of students on physical concepts and processes, as it will be further detailed. The paper is organized as follows: in the next section, the material and methodology used during the Projects' development are described. Main results from the Projects' implementation are related in Section 3. Finally, the most remarkable conclusions derived from this work are commented in Section 4. Further information and details about the Projects can be found at www.uca.es/udinnovacion/portal.do?IDM=55&NM=3.

2 METHODOLOGY

The methodology used in the PI_14_016 Project ('Physics I') was based on the installation of Posters of Recreational Physics at the Physics laboratory, experiments conducted during the Laboratory classes, and the development of contents for the Online Class (*Aula Virtual*) of 'Physics I' at IES-UCA. This methodology was modified for the PI_14_017 Project ('Physics II') based on the evaluation of PI_14_016 results (as it will be further described), so it finally consisted on experiments of Recreational Physics conducted during several Theory classes of 'Physics II' (Figure 1), and a final illustrative seminar for the DAE, DIDPDE, and DTIE Degrees.

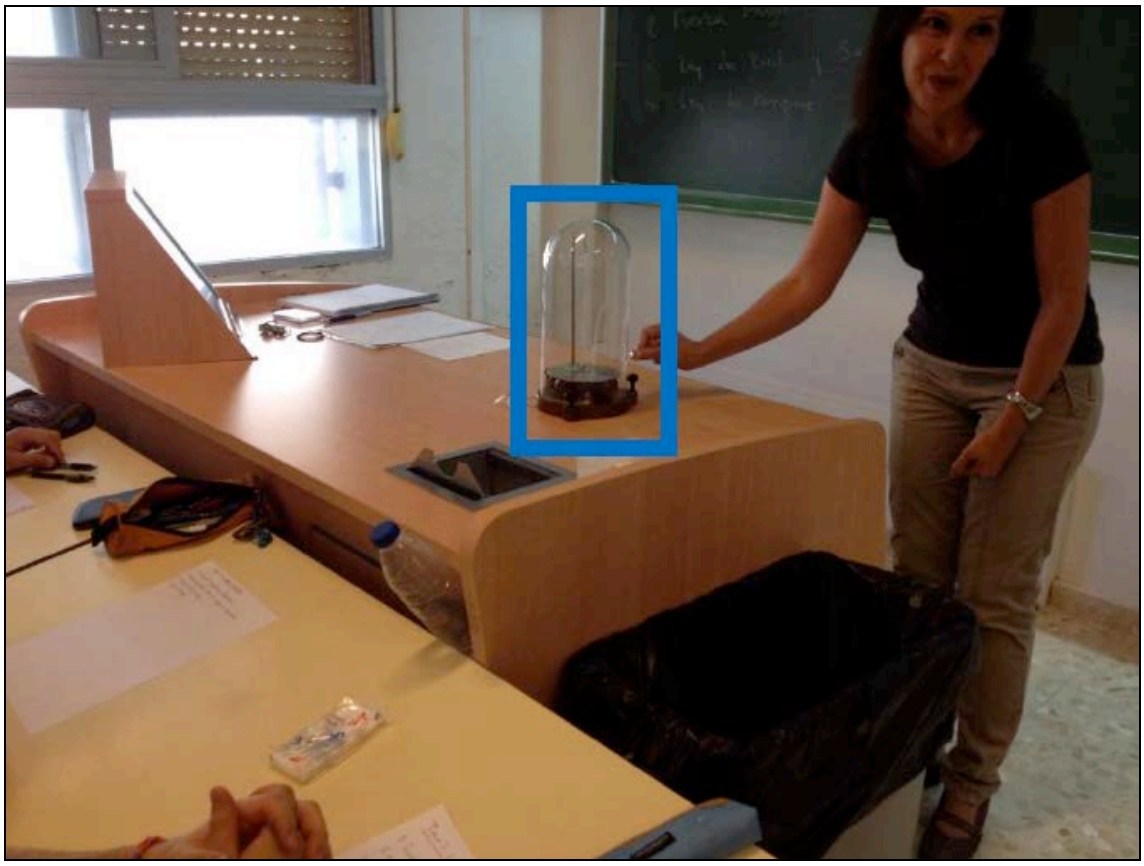

Figure 1. Professor Águeda Vázquez showing an antique device for the Ørsted method to the students.

2.1 Recreational Physics

Some of the Recreational Physics material and experiments used in the framework of the PI_14_016 and PI_14_017 Projects were the following:

Rigid solid dynamics

- Newton's chain: complex dynamics and compound forces.
- Newton's pendulum: momentum and energy conservation.
- Toy carousel: rotation dynamics and centripetal force.
- Toy duck in a ramp: gravity center.
- Toy walking-fisherman: gravity center and compound forces.
- Toy woodpecker: gravity center and friction processes.
- Yo-yo: rotation dynamics and conservation of mechanical energy.

Thermodynamics

- Candle inside an inverted cup: partial pressure of gases.
- Perpetual-motion bird: laws of thermodynamics, evaporation/adsorption.

Electromagnetism

- Balloon on a wall: electrostatic forces.
- Electric coil: magnetic induction.
- Electrolytic capacitor: electrolysis, capacitance.
- Gauss weapon: magnetic forces.
- Gold-leaf electroscope: electrostatics, antique instruments.
- Inverted magnets: magnetic fields.
- Lenz law set: magnetic induction.
- Levitron: magnetic force fields, rotation dynamics.
- Leyden bottle: capacitors, antique instruments.
- Magic wand: Van de Graaf generator, electrostatics.
- Magnetic board: magnetic forces.
- Magnetic paper: magnetic fields.
- Ørsted experiment: measurement of the Earth's magnetic field.
- Speaker: physical principles of a speaker.
- Thermal magnetic engine: Curie effect.
- Toy electric set: electric circuits.
- Vibrating magnets: magnetic forces.

2.2 Books, posters and other resources

Books

- Conversaciones de Física con mi perro, by C. Orzel [5]
- Electrotecnia 2º Bachillerato, by J. A. Fidalgo et al. [6]
- Experimentos científicos: electricidad y magnetismo, by M. Walker and D. Awuah [7]
- La Física de los superhéroes, by J. Kakalios. [8]
- La seducción de la Física, by C. Drösser [9]
- Los científicos y sus locos experimentos, by M. Goldsmith [10]
- Por amor a la Física, by W. Lewin [11]

Posters

- El origen de la Física. ¿Quién, cuándo y qué? (*The origin of Physics. Who, when and what?*).
- La Física de los superhéroes (*The Physics of superheroes*).

Online resources

- PDF books.
- Recreational Physics contents.
- Guides and manuals.

2.3 Evaluation

The evaluation of results of the Projects was carried out by a questionnaire to be filled by the students at the end of the Course. The questionnaire was anonymous and it was filled by 47 students of the Degree on Aerospace Engineering (DAE), and 27 students of the Degree on Industry Design and Product Development Engineering (DIDPDE). The questions were about the interest and possible improvements relative to the contents of the Teaching Innovation Projects, and they were the following:

1. Do you like the physical phenomena being shown by Recreational Physics Experiments and toys, complementing the Physics subjects? (YES/NO)
2. Do you think these experiments help understanding physical concepts? (YES/NO)

3. The objective of the Teaching Innovation Projects was, among others, to make Physics closer and funnier to the students. Do you think this objective was achieved? (YES/NO)
4. Do you think there were not enough experiments? (YES/NO)
5. What was the experiment you enjoyed the most? Why?
6. Your personal opinion is important for us. Did you like the Projects? Do you miss something? What would you remark?
7. Do you think the application of these Projects to further courses being convenient? (YES/NO)
8. Other objective of the Projects was to use alternative teaching methods for Applied Physics. Do you think this kind of teaching methodology being positive, or you actually prefer traditional methods?
9. Did you visit the Online Class section 'Physics is funny'? (YES/NO). What did you missed on it?
10. What would you improve for the classes, as well as for new possible experiments?

3 RESULTS

The answers of the students for the YES/NO questions of the questionnaire are shown in Figures 2 and 3.

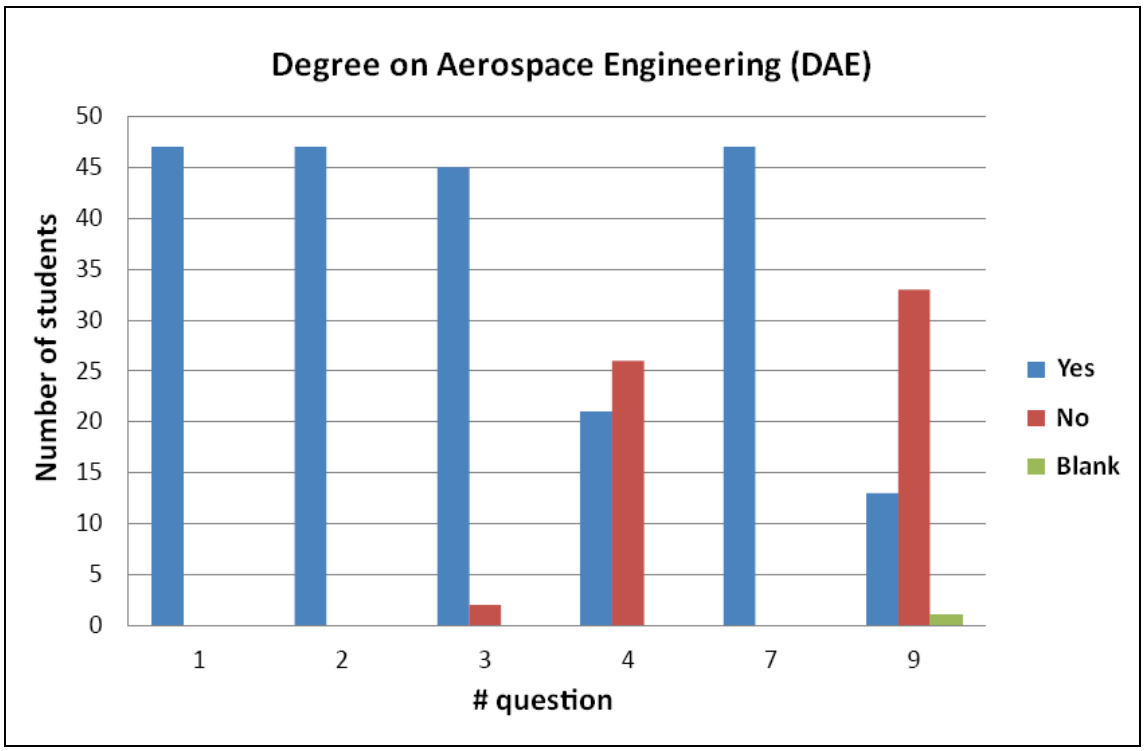

Figure 2. Results for the answers to the YES/NO questions of the questionnaire to the DAE students.

The answers to the questions 1 and 2 are YES for 100% of cases, showing the interest of recreational experiments for the students, as well as they ability to help understanding physical concepts. The answer to question 3 was NO for only 4% of DAE students, so it can be concluded the main objective of the Projects to have been mostly achieved. According to the answers to question 4, more than 40% of students would like more experiments to be shown in classes, showing again the interest of this kind of activities for them. This becomes also patent from the 100% of positive answers to question 7, since all students consider the implementation of Projects like these convenient for further courses. In contrast with the previous results, negative answers to question 9 were predominant for both DAE (70%) and DIDPDE (51%) students, which shows the contents included in the Online Class having less interest for the students than the recreational experiments; the reason for that is not completely

clear from this study, apart that students seem to prefer more direct and participative activities rather than learning from readable material.

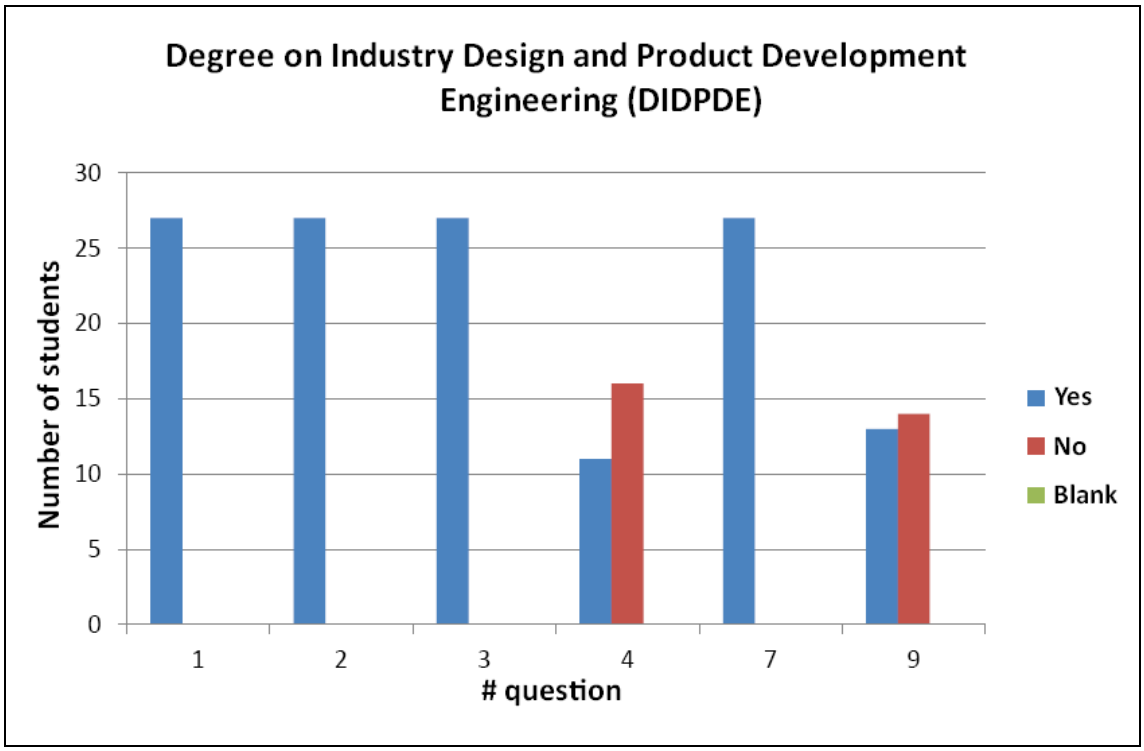

Figure 3. The same as in Figure 2 but for the DIDPDE students.

Answers to question 5 show that the most interesting experiments for students were the Van de Graaf generator, the magic wand, the Levitron, and the Gauss weapon; it is remarkable that all of them have to do with electromagnetism. According to the answers to questions 6, 8 and 10, the students have enjoyed the experiments related to the Projects, and they consider convenient to complement theory classes of Physics –as well as other subjects of their Degrees– with this kind of activities. They mostly would like a higher number of experiments and more reduced class groups to conduct them. Some of the students' answers are quoted as follows:

> *In general, the Project is interesting for me, since sometimes the subjects are excessively theoretical and we think: 'what is the utility of all of this?' This kind of experiments show the very applicability of the subject.*
>
> *Enjoyed the experience; I think Engineering consists on applying theory to practice, and it is a good way to open our minds in that respect.*
>
> *The experience is positive because you are more motivated by practical activities and understand better what you have to learn.*
>
> *It is positive because you approach Physics from a different viewpoint.*

4 CONCLUDING REMARKS

The main conclusions derived from the results of the PI_14_016 and PI_14_017 Teaching Innovation Projects can be summarized as follows:

i) This kind of activities, mainly Recreational Physics Experiments, increases significantly the interest of students on Physics and Science principles, concepts and contents.

ii) Students show a considerable interest on learning more about recreational experiments and the physical phenomena involved.

iii) The Projects have promoted the enjoying of students in learning and analyzing physical processes. It is remarkable that this sensation is extendible to the teachers involved in these activities.

Hence, it can be concluded that the two Projects achieved their main objective of making the Physics subjects closer and more attractive to the students, helping them to understand and learn theoretical contents. It would be desirable to extend this kind of activities to further Physics courses and even other subjects and matters of the different Engineering Degrees.

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