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Disclosure day on relativity: A science activity beyond the classroom

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Abstract

An important goal for students in engineering education is the ability to present and defend a project in front of a technical audience. We have designed an activity for helping students to work the independent learning and communication skills, while they are introduced in the dynamics of a conference. In this activity, students prepare and present a poster at a popular physics conference on relativity. This activity is shown to provide them with communication skills, related to generic skills at the core of *Universitat Politècnica de Catalunya* (UPC) degrees, and which are relevant in most of the duties of an engineer.

Keywords: RIMA project, Science communication, communication skills, autonomous learning, team work.

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1. Introduction

Engineering studies, among many other goals, prepare students to be able to understand, develop and present technical and scientific contents to other members of the community. In this way, oral communication in their mother tongue is an essential component in the education of engineering students to prepare them for their professional careers (Consell de Govern de la UPC , 2008; Institut de Ciències de l'Educació, 2008). In the past, engineering education had been directed towards the development of technical knowledge and skills, but literature about engineering education is increasingly pointing to the need to reconsider the enhancement of oral communication and team working, as well as other skills, such as foreign language skills (Versteele, Berbers & Londers, 2012).

An important part of the work carried out by engineers has been linked to structure and convey concepts related to different projects to others in a successful manner. In the last courses of the engineering studies, students may develop and present different projects in the field of engineering that should be usually defended in the classroom, with peers and faculty (Keane & Gibson, 1999). But this controlled context is far from what they might face in a future social development of their carriers as engineers or scientists (Ravesteijn, De Graaff & Kroesen, 2006)

To fill this gap, GIDF[*] (Physics Teaching Community of Practice, *Grup d'Interès en la Docència de la Física*) and GRAPAU[†] (Autonomous Learning Community of Practice, *Grup de Recerca en Aprenentatge Autònom*), Communities of Practice (CoP) involved in ICE-UPC RIMA[‡] Project of *Universitat Politècnica de Catalunya* (UPC), build on its experience in teaching improvement, have developed a jointly project in which students should work on independent learning, team collaboration and communication skills(Salán, Martínez-Martínez, Portet & Torra, 2012; Marcé-Nogué, Salán, Aragoneses, Bernat, Escrig, Otero, Rupérez & Illescas, 2012).

These two CoP have selected "Special Relativity" an optional course taught at the last year in engineering studies at School of Industrial and Aeronautic Engineering of Terrassa (UPC) and linked it to an activity performed annually in a local museum (UPC, 2011). The activity is called a Relativity Dissemination Day (RDD), held annually in February in Terrassa (Barcelona) (Terrassa Digital, 2017). Of course, due to the characteristics of the course, only students truly interested in science should enroll it.

The goal of the RDD is to get science close to society, by means of including several talks/speeches given by scientists and/or science communicators, all of them on relativity and closely related areas (cosmology, astrophysics or quantum mechanics). In addition to conferences, some less formal activities are developed, as small workshops, astronomical observations or science fiction movie-forums, in which the audience is invited to participate actively. By considering this background, it is suitable to include a poster session where students can present their work and explain it to RDD audience interested in their details. By doing this, students deal with the fact of having to present and defend their previous research in front of a non-expert audience, which also are very interested in what they have been working on.

2. Description of the course

In order to prepare students towards their final exhibition in the RDD, the subject, 35 teaching hours, is divided into three parts, assessed in three different ways. The first 24 hours of the course are devoted to a more classical teaching focusing, with lectures and problem solving, in order to provide the main ideas and concepts of special relativity to students. During this first phase students are evaluated by delivering weekly problems.

[*] GIDF(*Grup d'Interès en la Docència de la Física*): Physics Teaching Community of Practice
[†] GRAPAU (*Grup de Recerca en Aprenentatge Autònom*): Autonomous Learning Community of Practice
[‡] RIMA (*Recerca i Innovacio en Metodologies de Aprenentatge*): Research and Innovation in Learning Methodologies

In an 8 hours second phase of the courses, faculty from other universities or different Schools of UPC itself are invited to give speeches on topics related to relativity. These other lectures treat either practical aspects of relativity or the latest research being carried out. In the metropolitan area of Barcelona and its surroundings there are several universities, with physics research groups, especially at *Universitat Politècnica de Catalunya* (UPC), *Universitat Autònoma de Barcelona* (UAB) and *Universitat de Barcelona* (UB). This provides a wide variety of researchers and professors experts in relativity, cosmology, astrophysics, nuclear physics and history of science, issues closely linked to the courses content. These conferences allow students to:

- To get an overview of science and know examples of its relevance in the development of engineering and society. It also allows them to see the relevance of comprehensive training to work as an engineer.
- To know about current research in physics and the importance of engineering in complex experiments being carried out in that discipline.
- To observe different communication techniques in a lecture by people who tend to present their research at scientific conferences. This allows students to think about how to structure their presentations.

Some of the topics covered in the lectures are: gravitational waves, science and engineering of the Manhattan Project, dark matter, interstellar travel, Einstein's life, the operation of nuclear power plants and the history of physics (UPC, 2017). Even though only four speeches were delivered at each special relativity course, through the last three courses up to nine different speeches have been delivered. In order to know the opinion of students regarding the conference and to assess their interest and acceptance they were asked to answer a general survey (figure 1).

Survey on the speeches

Rate from 0 (disagree) to 4 (agree) the next items of the speeches:

1.- I have found interesting the content of the speech.

2.- The speech has provided me information that I didn't know.

3.- The speaker was clear in his/her presentation.

4.- I have found suitable that these talks are organized in the framework of the course.

5.- I am interested in enlarging my scientific culture.

6.- I have found it relevant for my preparation having a broad scientific culture.

7.- I think that not enough talks are offer during the engineering studies.

8.- I think I am aware of the latest developments in science and technology.

9.- I would rather prefer to have devoted more hours to lectures and problem solving than to talks.

10.- If should be another course on modern science or history of science in campus I would enroll in it.

11.- What other scientific contents you would like to be treated in next talks?

Figure 1. Survey to evaluate the impact of the speeches on students.

The third part of the course is a poster development. During the course, teacher suggests different problems to be developed by students, all related to the concepts studied in class or presented in some of the speeches. Each of the problems implies developing in depth a specific concept of special relativity. Some of them imply solving some of the many paradoxes in special relativity. Students, depending on their concerns may also propose alternate problems to study and solve, whose

suitability will be considered by teacher. Throughout the course, professor monitors the progress of the work. Delivery guidelines are given to students, which they can also check online.

Students work assessment contains several components:

- Correction of problems given weekly during the regular lectures (representing 30 % of the grade).
- A test at the end of the first phase (representing 20 % of the grade). In the test they have to solve two problems on special relativity and also to answer questions on the speeches of invited speakers.
- Poster evaluation. This assessment is made equally between students and teachers. They have been given detailed instructions and a rubric (figure 2) to grade the different aspects of the posters. This allows students to develop their own poster having this in mind, which helps them to work relevant aspects of it. The poster is presented in the classroom at the end of the course. Fellow students must complete the rubric and evaluate the points indicated in it, just as teacher will do. This accounts for 50 % of the overall mark. This grading considers, on the one hand, the technical resolution of the problem on relativity, and on the other hand, the ability of students to expose and get their audience to understand the work both, in the printed poster and in their oral presentation of it.

3. Presentation and defense of the poster to an external audience.

It is important to make clear the social context in which students presented their work. Terrassa has the second biggest University campus of Catalonia, after Barcelona. It was recognized as a City of Science and Innovation by the Spanish government. Five different universities have presence in the town. It is in one of the schools of *Universitat Politècnica de Catalunya* (UPC), but opened to all students on campus, where the course on special relativity is taught. The city also has the national museum: *Museu Nacional de la Ciència i la Tècnica de Catalunya* (MNACTEC) which depends on the Catalan government (Museu de la Ciencia I de la Tecnica de Catalunya, 2017). There is also an astronomical amateur association (UPC, 2017). It is in collaboration with the astronomical group, the Museum, the Terrassa City Council and the University, that every February since 2008 the Dissemination Day on Relativity commemorates the visit of Albert Einstein to Terrassa in 1923 (Terrassa Digital, 2017).

This day is dedicated to highlight, acknowledge and extol the figure of Albert Einstein and relativity closer to society. The program outline is maintained every year. Three lectures are given by researchers and science communicators. Two science film symposia are held as well as different physics workshops and an astronomical observation. The goal is to bring science to society, to promote the dialogue between scientists and the broad audience and to raise awareness of the importance of science in our welfare society.

It is in this environment where Special Relativity students expose their work. The dissemination day lasts one whole Saturday (from 10 am to 8 pm). The audience shows a great interest in science, although their scientific knowledge is very diverse (from teachers and students of high school and college, to science buffs, people with varying technical training but with concern for scientific knowledge). The documentation delivered to the audience includes a survey for his assessment of student presentations. Since the day takes place right after finishing the first semester (last weekend in February) the results of these surveys are not take part of the formal evaluation of students, but they allow us to evaluate the teaching activity carried out. Students have previously received the

rubric that would be distributed to those attending the conference so that, in preparing the poster, they take into account important aspects for a good communication of their work.

Rubric for the poster presentation

Rate from 0 (disagree) to 4 (agree) the next items of the posters:

Poster.

1.- General visual impact. Is the poster visually attractive?

2.- Communication items (typography, color, functionality, …). Is the poster easily read? Do figures and plots help its understanding?

3.- Presentation of the contents. Does the poster reflect the work? Is it self-contained?

4.- Structure, aesthetics, coherence, and graphic harmony.

Oral.

5.- Oral exhibition. Is the presentation stimulating? Is it easy to follow? Does the presenter aim to be understood?

6.- Structure of the oral presentation. Is the goal clear from the beginning? Is there a clear reasoning? Is the presentation structured?

7.- Duration. The time has been suitable for each part of the description.

8.- Group work. All the members have taken part actively in the presentation and the question.

9.- Questions/Answers. The answers to the questions have been clarifying and efficient.

Global.

10.- Creativity. Is the work, in global, original, with stile and with a good communicative strategy?

Figure 2. Rubric to be used by the audience to grade each poster. The rubric is also used by students to prepare the poster and to evaluate their peers in the classroom presentation.

4. Results

Based on the results of students in the different activities evaluated and on the different surveys we can assess the results of the project. We can measure the satisfaction and assessment of students and the goals achieved by them through the experience.

4.1.1. Rating of the speeches

All the activities performed follow the goal of improving students' ability to defend their research in public, be it either expert or lay on the subject. First of these activities, invited speech, was received very favorably by students (see figure 3). They value positively the fact of being offered popular science lectures given by external experts on different aspects related to the main course. According to the surveys, many of students find that they have little knowledge of the science that is being investigated today, and they feel they do not have many opportunities to increase it within the curriculum of studies.

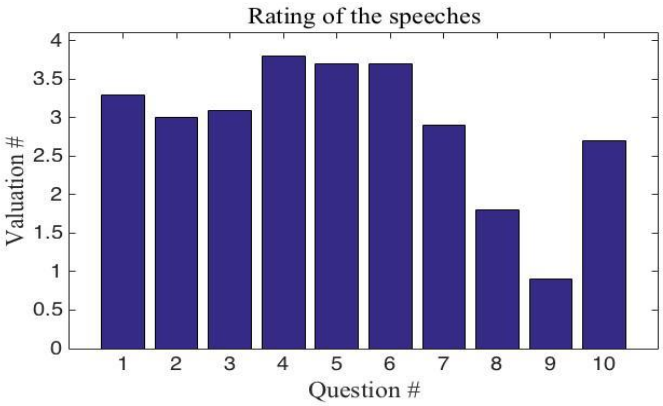

Figure 3. Positive students evaluation about invited speeches. Questions related are in figure 1.

One of the aspects that students were in more agreement (questions 4, 5 and 6 of survey 1) is that they find important for their career as engineers to have a broad knowledge of the science that is being investigated today, so they greatly appreciate the opportunities offered to them in the course to improve this knowledge in science and innovation. Some of the subjects they show interest in are those of intense research nowadays with clear links to engineering, such as quantum mechanics, particle accelerators or nuclear physics. In particular, when asked for other subjects of interest in question 11 of survey 1, 47% of students agreed in quantum physics and applications for day life.

4.1.2. Rating of the poster defense in the classroom

First poster presentation is in the classroom, with their peers and the teacher. In this session, each work is evaluated independently by students and by teacher. Every student has a rubric and a template. They all had those documents when developing the poster, so they all know the key aspects that are going to be evaluated. The grading that students do of their colleagues work is anonymous, and it mostly coincides with that made by professor. The difference between both re views is at most one point over 10. This shows that they have assimilated and are aware of the important aspects of the presentation and defense of the poster (figure 4). The comments they write on the evaluated works tend to be demanding on the contents and on the communication techniques. The fact of having guidelines helps them to develop a better work and to grade in a rigorous manner.

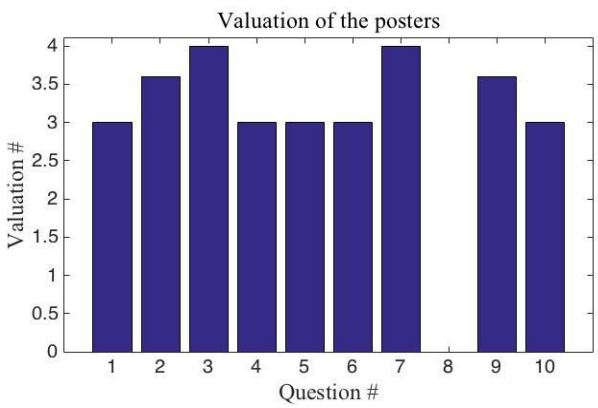

Figure 4. Poster evaluation by means of a rubric. Questions related are shown in figure 2.

4.1.3. Rating the defense during the dissemination day

The evaluation that the public of the DDR made on the poster presentation is highly positive (see figure 4). The aspects most highly graded make reference to the communication items of the poster and of the answers to the questions they formulate. None of the items to grade had a lower mark than three over four. Some of the people showed interest in having the electronic version of some of the posters. It has to be mentioned that this poster activity is viewed from the public as a close approach, one to one, of science to society. That is why we consider that is also attains the goal of getting society to know how science works.

As consequence of this poster session, a science teacher of a high school invited engineering students to present their works to younger high school students, as an introduction to special relativity is also treated in high school. Some students of the course and the professor went to the high school on Barcelona. The professor gave an introductory talk and engineering students explained their posters to high school students, reinforcing their experience.

4.1.4. Rating the activities of autonomous learning

By observing the surveys (see survey 3 and Fig. 4), students mostly agree that the project is suitable for the content of the course. Also the management of the contents online is good for the subject. They also find positive and fair the grading system chosen, and they feel that the global project helps them in their learning, all of them with more than three points. Aspects 2 and 3 from survey 3 have to be analyzed in a different way, as an intermediate punctuation would be optimal when referring to balance of difficulty and used time. This aspect is over the mean but not too much.

5. Conclusions

In this paper we have presented and described the project we developed to involve engineering students in the dynamics of a conference, with all the tasks that it implies. In order to success in the project, students have had to develop communication, autonomous learning, and team work skills (Versteele, Berbers & Londers, 2012; Ravesteijn, De Graaff & Kroesen, 2006; Lappalainen, 2009; Jennings & Ferguson, 1995). All these skills are present in the core goals of the engineering studies, and are key tools they will need in their future jobs (Ravesteijn, De Graaff & Kroesen, 2006; Lappalainen, 2009). The overall project development and public defense of the poster has proven to be a useful tool for learning contents and methodologies. After the analysis of the surveys answered by students we can conclude that the different steps followed during the course helped students to understand the importance of professional science and engineering communication. They also gained communication abilities and were able to detect the most relevant concepts of their research to synthesize in an agile way. Through this project we have worked particular aspects of autonomous learning (one of the objectives of GRAPAU) and communication techniques, both visual and oral, obtaining satisfactory results. There has also been made a positive social connection between students and the university with society, gaining external recognition of the public and an added motivation. Engineering students directly understand the importance of the dissemination of science to society (one of GIDF main goals), both as part of their work as future engineers or researchers, and as the social need to understand how public resources are allocated and how research, basic and applied may affect it. Ideally, students' skills in oral communication, which reinforces these social competences, should be initiated at the secondary school level (Ravesteiin, De Graaff & Kroesen, 2006).

During the development of this project it has been noticed the importance of clear guidelines. They are keys to achieve the goals of solving a scientific problem on the one hand and success in the dissemination of its results on the other. Supervision is also needed to ensure that students will be able to address the problem, as some of the problems proposed by them may be beyond reach. This project can be easily exported to other courses and undergraduate studies, and promises to help students at a college level to improve their communication skills, as well as to get familiar with workshop and conference procedures and dynamics.

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