

Thirty years of teaching graphic engineering projects at the Barcelona School of Engineering

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Abstract: The Projects department of the Barcelona School of Industrial Technical Engineering (EUETIB) was one of the first to opt for working with parametric and associative CAD software in the subject of Drawing, a pioneer in implementing SolidWorks (SW) in graphic engineering learning. The parametric conception combined with the intelligent geometric functions, and the variational and bidirectional design, allowed the recently graduated student body to have knowledge at the forefront of the moment. The 09-10 academic year began degree studies adapted to the European Higher Education Area. The applied methodology emphasized students as protagonists of the learning process and was developed in ECTS credits, providing significant improvements in the teaching of spatial geometry. In the remodeling of the subject, the idea of a Project was promoted, in a group and in a non-face-to-face way. The project involves developing skills related to the ability to spatial vision and knowledge of graphic representation techniques using computer-aided design. The autonomous learning competence is valued, based on carrying out the assigned tasks in the foreseen time, working with the indicated sources of information, in accordance with the guidelines set by the teaching staff. Since the 10-11 academic year, the author of this communication has asked his students to put together a video with a cinematic animation of his project. The best project videos can be seen in a YouTube playlist. The videos are a complementary tool for the development of the graphic engineering Project.

Keywords: project, SolidWorks, YouTube, teamwork, graphic engineering.

1 Introduction

The Barcelona School of Engineering was born in 1850, under a scheme of basic education and expansion together with the centers of Seville, Vergara and the Royal Industrial Institute of Madrid. The first qualified engineers in Spain emerged from the Barcelona School of Engineering, as first and second class engineers, and later as engineers and industrial experts. Being an expert could obtain the degree of industrial engineering in six months. It was about approving the disciplines of mechanics for chemical specialty students and chemistry for mechanical experts.

As of 1895, although the director of the Barcelona School of Engineering was the same person for both studies, engineers and experts, access to the Higher School of Engineering was segregated from the Industrial School of Experts. It should be pointed out that from the beginning until the early 60's, both schools were located in the same historic premises as the Industrial School, located at 187 Urgell Street [1]. Starting in the 1960, the University Zone would be established on Diagonal Avenue, and the Barcelona School of Industrial Engineering (ETSEIB) would be founded at number 647, while experts would continue to be trained at the Barcelona School of Industrial Technical Engineering (EUETIB), predecessor of the current Barcelona East School of Engineering (EEBE), implanted since 2006 in the new Diagonal Besós campus of the Polytechnic University of Catalonia, near the modern Fórum neighborhood

This communication provides knowledge about the last thirty years of teaching graphic engineering projects at the EUETIB-EEBE of the Polytechnic University of Catalonia (UPC).

In the 1972 study plan of the EUETIB (which was in force until the 94-95 academic year) the subject of Technical Drawing (code 1401) taught 4 hours of drawing per week throughout the first year (between September and June). The teachers who taught the subject at that time were Joan Farrerons Oller, Pere Moreno and Pau Sola. Plan 72 received different modifications over the years, incorporating at the beginning of the 90's part of the teaching with AutoCAD support. The subject was unique, but it was adapted to each of the specialties, for example to the specialty of Electronic Engineering, in addition to AutoCAD, the TANGO computer-assisted electronic engineering package was also taught. The program facilitated the representation of electronic schematics, the realization of printed circuits, the generation of the necessary files for computer-aided manufacturing (CAM) and the design and simulation of PLD. Along with TANGO, Pspice was also explained in the simulation of digital and analog circuits. In the mechanical specialty, in addition to AutoCAD, the specific mechanical design program Mechanical Desktop and Rhinoceros were used. The Projects Department (Graphic Engineering) also offered, with great success in terms of acceptance by the students, subjects such as Infographics for the creation of realistic environments and synthetic images, where the main application was 3D StudioMAX, although POSER was also used, BRYCES and Terragen.

In the 1995 study plan, a part of the subject of Industrial Drawing for Computer Aided Design (CAD-DAO) was consolidated. The architects of this change of plan in the subject of Drawing were the professors Joan Antoni Ram rez Miralles, Ramon Blesa Serrano and Magi Galindo Anguera. They did not start from scratch, because a portion of the subject had been taught in CAD for years, and part of the syllabus had been collected in the book that the three professors had published shortly before entitled " DAO 2D Ra z del Dise o Industrial" [2] .

The 1995 study plan brought about an update-modernization in all the subjects taught at the EUETIB, which implied in September 1995 the hiring of a dozen young professors from the different departments, most of them recently graduated, among them the one who signs this communication for the Department of Graphic Engineering (then called the Department of Projects in the EUETIB).

The CAD-DAO subject prepared by professors Ram rez, Blesa and Galindo used the Autocad program, then a widely used standard in industrial design. But as of 1997, the Department of Graphic Engineering of the EUETIB decided to bet on SolidWorks as a graphic design tool, and in general on ICT as an improvement in learning graphic engineering techniques in Industrial Engineering [3] .

2 A new computer program to facilitate graphic learning

The evolution of computer networks, the increase in the calculation power of computers, and the generation of graphic standards (GKS) and user-oriented interfaces (MOTIF) caused that, at the end of the 90s, work began with software of parametric, variational and associative CAD [4]. For this reason, the EUETIB was one of the pioneer centers in the acquisition of SolidWorks software in Spanish universities that began teaching with this type of software. The parametric conception combined with the intelligent geometric functions (Features) and the bidirectional variational and associative design, allowed the recently graduated students to have cutting-edge knowledge of the moment.

The decision to choose SolidWorks was not an easy one. Other applications such as CATIA (Dassault), Unigraphics (EDS McDonnell Douglas), CADD5 (Computer vision), AutoSURF and Mechanical Destop (Autodesk) or I-DEAS (Structural Dynamics Research Center) were the CAD programs that were widely used. massive in engineering. Among all, ProEngineer (Parametric) was the sales leader in 1996 with 95% of sales worldwide. However, the Department of Graphic Engineering of the EUETIB decided to acquire SolidWorks due to the functionality of the applications and complements, the increase in its use in the Catalan industry, the training and support of the distributor, the necessary hardware and a reasonable cost.

The reason for the software change can be found explained in an article that was published in 2010 signed by the professors of the subject at the time [5]. This article highlighted the reasons why SolidWorks began to be used at the EUETIB before the beginning of the 20th century: *"The familiar and intuitive environment, the ease*

of learning by the students, the speed of executing commands, and the great amount of teaching material available". Students and teachers had free licenses and various online resources, exercises, presentations, videos, notes...

3 Graphic engineering project and European Higher Education Area

In the 2009-2010 academic year, the EUETIB began its undergraduate studies adapted to the European Higher Education Area. Degree studies that since then had the purpose of obtaining from the student a general training aimed at preparing professional practice. The methodology applied in this new approach emphasized students as protagonists of the learning process and was developed in ECTS credits (European Credit Transfer and Accumulation System), providing significant improvements in the teaching of spatial geometry [6].

In the remodeling of the subject by the 2009 study plan (currently in force in the EEBE), the idea of a Project was promoted, which would be developed in a group of three students, and would be worked on remotely. The professors of the department at the EUETIB who started the remodeling were: Andrés García, Enric Codina, Francesc Alpiste, Jordi Torner, José Luis Rodríguez, José Val-verde, Josep Pardina, Miguel Brigos, Oscar Farrerons, Noelia Olmedo, Pedro V. Gabriel, Pep Ibáñez, Sergi Gómez, Francesc Tensa, José A. Moreno, Jordi Ivern, Bárbara Sureda, Joan Antoni Ramírez, Pau Sola and Pere Moreno. The teaching methodology and the empowerment of the Project represented new opportunities in the field of Graphic Engineering [7].

The project that students must design since then represents the integration of the knowledge and skills obtained during the course. However, the challenge of carrying out a project leads students to investigate for themselves, which is why they normally acquire more skills than those formally taught in class. From that moment, all the students of the five grades that studied in the EUETIB (Mechanics, Industrial and Automatic Electronics, Electricity, Chemistry, Biomedical) develop a project in SolidWorks.

In figures 1 and 2 you can see two of the first projects developed autonomously by the students following the previous premises.



Fig. 1. Starter motor, 2013. Students: Sánchez, Ferrán, Paulí, Bustos. Professor: Farrerons.



Fig. 2. Office lamp, 2012. Students: Maja, Massip, Manubens. Professor: Farrerons.

4 The project at the Barcelona East School of Engineering (EEBE)

Since the 2016-2017 academic year, the EEBE has replaced the EUETIB. We have gone from the historic Industrial School on Urgell Street to the modern Besós Campus of the UPC, next to the Barcelona Forum and the beaches. The subject of Graphic Engineering (taught by the professors of the Department of Graphic and Design Engineering, DEGD), continues to be a core subject of 6 ECTS credits, which is now taught in seven engineering degrees (Mechanics, Industrial and Automatic Electronics, Electricity, Chemistry, Biomedical, Materials, Energy), with 750 students enrolled, divided into 25 groups, in which the subject is taught in Catalan, Spanish and English.

The Project of the Graphic Engineering subject involves developing skills related to the capacity for spatial vision and knowledge of graphic representation techniques, both through traditional methods of metric and descriptive geometry, and

through computer-aided design applications (SolidWorks). Specifically, the autonomous learning competence (level 1) is also valued, based on carrying out the assigned tasks in the foreseen time, working with the indicated sources of information, in accordance with the guidelines set by the teaching staff. For the realization of the project it is expected that the student will dedicate 45 hours of work, spread over 15 hours. of directed activities and 30h. autonomous learning. The project has a total weight in the grade of 20%, being one of the most valued elements of the evaluation of the autonomous learning competence [8].

5 YouTube project playlist

Since the 2010-2011 academic year, the author of this communication, who has been a professor of the Graphic Engineering subject uninterruptedly since 1995, has asked the students in his groups to, in addition to handing in the complete work with everything that is required of general form in the academic program of the subject, they also made a short video (maximum 3 minutes) with an animation of the kinematics of their project. The best videos of the brightest projects can be seen on the YouTube playlist titled “Projectes Expressió Gràfica (SolidWorks)” (<https://tinyurl.com/y4hbxzv9>), a channel that currently has a little over 300 subscribers. In addition to the projects for the Graphic Engineering subject (1st Q.), there are also projects for the Graphic Engineering Mechanical Design subject (5th Q, a compulsory subject for students on the Mechanical Engineering degree).

At the time of writing this communication, there are a total of 199 posted videos on the playlist, totaling almost two hundred thousand views, totaling more than 3,100 hours of viewing (with an average of 1 minute and 10 seconds of viewing per video). The 10 most viewed videos are highlighted in table 1, reviewing the course, semester and total number of views.

Table 1. Videos from the YouTube playlist of graphic engineering projects with the most views. (Own source).

<i>Video</i>	<i>Course</i>	<i>Semester</i>	<i>number of views</i>
Grapadora	15-16	Autumn	60.150
Ventilador	12-13	Autumn	16.300
Gato mecánico	15-16	Spring	9.190
Banqueta pianista	16-17	Autumn	6.320
Bomba hidráulica	12-13	Spring	3.810
Máquina coser Sigma	14-15	Autumn	3.580
Grúa da Vinci	13-14	Autumn	2.320
Fusil AK-47	14-15	Autumn	2.125
Subfusil Sten MK	20-21	Spring	1.710

A year of primacy with more videos viewed is not observed, but a video with many views ("Grapadora") stands out. Most views of the "Grapadora" video are made in the years 2017 (13,080), 2018 (18,871) and 2019 (16,777).

Looking at the general statistics of the YouTube channel, we can also know that 71.4% of the views are from men, and 21.6% from women, in a percentage similar to the number of students enrolled by gender.

The statistics, regarding the origin of the traffic source, indicate that 41.2% access through suggested videos, 22.2% through playlists, 17.2% through direct search on YouTube, 6.1% through external sources, and other diverse situations with lower percentages, which when grouped add up to 13.30%, as can be seen in Figure 3.

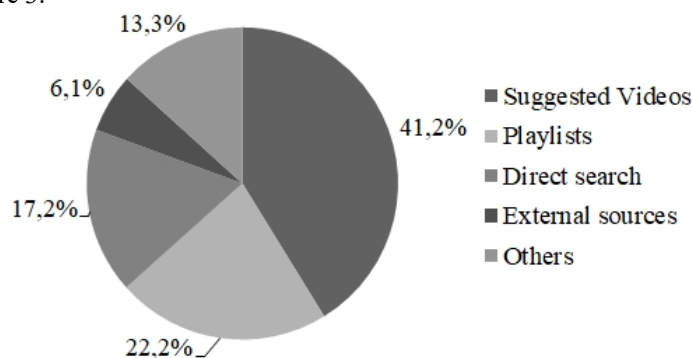


Fig. 3. Percentages in terms of origin of traffic source. (Own graph based on YouTube data from the playlist).

35.2% of views are identified as originating in Spain, according to YouTube statistics, 6.3% in Mexico, 1.1% in Brazil, and then continue with percentages below 1%: Colombia, USA, India, Indonesia, Peru and Vietnam, mainly, and with percentages of less than 0.1% of views, a long list of countries that reaches up to 31 nations.

97.5% of the views are made by users subscribed to the channel, while only 2.5% are users not subscribed to "Projectes Expressió Gràfica (SolidWorks)".

Another important piece of information that we can extract from the channel's YouTube statistics is the age range with the most views, which we can see in table 2. It can be clearly seen that more than half of the views are carried out by students (since they are in the age range of 18 to 24 years)..

Tabla 2. Table 2. Percentage of users who have carried out the visualizations according to the age range. (From YouTube playlist data).

13-17	18-24	25-34	35-44	45-54	55-99
1.5%	52.1%	33.0%	7.3%	4.8%	1.3%

The number of videos of projects for each course and semester is very variable, and depends on the number of groups and students that have been in each semester, and the quality of the projects themselves. Despite this diversity, we did want to analyze the number of videos per quarter, as can be seen in figure 4.

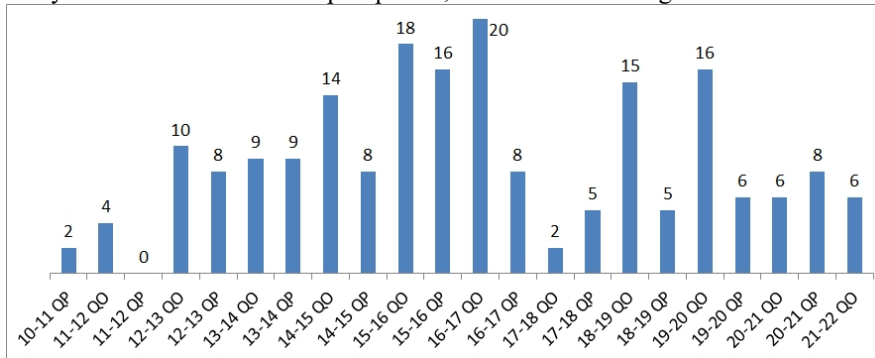


Fig. 4. Number of videos according to course and semester. (Own source).

Figure 4 shows that the largest number of videos is concentrated between the autumn of the 15-16 academic year and the autumn of the 16-17 academic year. However, it does not seem that any evidence can be concluded regarding the courses (since they depend on many other variables, such as the timetable, the number of students, etc...). It can be verified that the total number of videos in figure 1 does not add up to the 199 total, because there are 4 videos that are not available on YouTube (basically for reasons of music property rights claims). Yes, it was possible to verify that there are 60% more videos (120 compared to 75) in the autumn semester than in the Spring semester, but this is only attributable to the fact that the number of students who take the EG subject in autumn is much higher in autumn than in spring.

The theme of the projects is very varied, predominantly mechanical devices (bicycle, scooter, various motors...), small appliances (blender, washing machine, dryer, pencil sharpener, clock...), musical instruments (piano, saxophone, guitar, flute...), Lego Technic (motorcycle, StarWars...), drones, printers, mixers, staplers, lighters... But what most characterizes the theme is its variety. For example, we can see in figures 5 and 6, two captures of the videos of the last projects delivered in the autumn semester of the 21-22 academic year.



Fig. 5 (Left). Blender, 2022. Students: Gómez, Iriondo, Alfonseca. Professor: Farrerons

Fig. 6 (Right). Ice cream spoon, 2022. Students: Blanes, Terricabras, Contreras, Wojtaszczyk. Professor: Farrerons.

6 Conclusions

The Projects department of the former EUETIB was one of the first university centers in Spain that opted for working with parametric, variational and associative CAD software. At first, mainly with AutoCAD, but also with specific programs for specialties.

As of 1997, the Department of Graphic Engineering of the EUTIB opted for SolidWorks, which meant the consolidation of the Drawing subject that had been updated in the then recent 2009 Study Plan.

The transfer of the EUETIB to the new Diagonal Besós campus of the Polytechnic University of Catalonia, with the creation of the Barcelona East School of Engineering, meant consolidating and strengthening the subject of Graphic Engineering, which since then has been taught to 750 students of 1st. semester, in the 7 engineering degrees of the EEBE. The commitment to autonomous learning as part of the content of the subject, through the project of an engineering-based mechanism, involves developing skills related to the ability to spatial vision and knowledge of graphic representation techniques, reinforcing traditional methods of metric geometry and geometric geometry. descriptive, through computer-aided design applications.

Since the 2010-2011 academic year, the best projects of the Graphic Engineering subject, developed with SolidWorks, from the groups corresponding to the author of this communication, are visible in a simple and didactic way, thanks to the YouTube playlist that accumulates almost 200 videos of Graphic Engineering projects, which is a very effective tool to explain to students what is expected of them in the development of their own project.

Nothing can be concluded from the statistics of the video playback list beyond the variability of the number of videos per course/semester, the number of views, the origin of the visitors or the themes of the videos. Despite the fact that only a

fifth of the views of the videos correspond to women, it is a fact that broadly coincides with the historical average of girls enrolled in industrial engineering degrees at the EUETIB-EEBE.

As a final reflection, it can be affirmed that the use of technologies in graphic engineering, in general and specifically SW, and the videos uploaded on YouTube of projects of other students of the subject, allow to increase the efficiency and quality of the works. carried out, and consequently also of the teaching and learning imparted.

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