



APPLICATION OF INNOVATIVE SOFTWARE TO THE SUBJECT PROJECT I OF THE DEGREE IN ENGINEERING IN INDUSTRIAL TECHNOLOGIES (GETI)

Irene Buj-Corral

Escola Tecnica Superior d'Enginyeria Industrial de Barcelona, Universitat Politècnica de Catalunya
Barcelona, Spain
0000-0003-4058-4162

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ABSTRACT

In this work the results about the use of innovative software in the subject Project I is presented. The subject is given in the Degree in Engineering in Industrial Technologies (GETI) in the School of Industrial Engineering of Barcelona (ETSEIB) of Universitat Politècnica de Catalunya (UPC). In Project I, small groups of 12 students or less are defined, with the purpose of developing a collaborative project along one semester. The project discussed in this work was prepared by two different departments: Mechanical Engineering and Statistics and Operative Investigation. It deals with the measurement of shaft diameters with a micrometre, in order to evaluate the measuring system employed. Traditionally, many activities of the subject were recorded in handwritten reports. The present academic year, within the frame of the project EQUIPA'T (equip yourself), innovative software was applied to the subject. As for the methodology, first the teachers attended a training course. Then, the application of innovative software to the subject was planned. Finally, it was implemented. Google forms was used in the first and last classes to gather information to prepare subgroups of students and to evaluate the subject respectively, Edpuzzle was employed to add questions to videos about two lessons of the manufacturing area: metrology and

turning, and Trello was used to manage the design of a 3D printed support by different teams of students. In subsequent years, the application of new software is expected.

1 INTRODUCTION

1.1 Description of the subject Project I

The subject Project I is given in the second year of the Degree in Engineering in Industrial Technologies (GETI) of the School of Industrial Engineering of Barcelona (ETSEIB) of Universitat Politècnica de Catalunya (UPC). It is a mandatory subject, although the students are divided into small groups with 12 students or less, with a specific theme for the project. The Department of Mechanical Engineering, in collaboration with the Statistics and Operative Investigation Department, offers the following subject:

Are we measuring correctly the parts that we manufacture? In this project, the measuring system for shaft diameters (consisting of using a micrometre and a support) is evaluated. An R&R (Repeatability and Reproducibility) study is used for this purpose.

1.2 Background of the research

In the past, several authors have dealt with innovative software in the engineering area. For example, in the US, in 2011, a new software was developed and presented in order to teach Digital Signal Processing [1]. Other authors have applied existing software to improve teaching in the Engineering area, for example Labviews for data acquisition [2].

On the other hand, some technical universities develop group-environment courses in order to help the students developing employability skills such as team-work, communication skills, problem-solving, organizing, etc. [3,4]. In this sense, the Barcelona School of Industrial Engineering (ETSEIB) implemented the subject Project I with the new GETI degree in 2010. The students are divided into smaller teams of 3 or 4 components, and the subject is evaluated by means of three successive presentations (with a written report and an oral presentation). Some results about the evaluation of the subject were presented in the CIDUI2014 conference [5], and lead to the publication of a journal paper [6].

In year 2017 an important innovation was added to the project about the evaluation of the measuring system. It consists of the design and manufacture of a 3D printed support that helps to fix the micrometer and the shafts when measuring (Figure 1). An example of a support was presented in the CNIM2021 conference [7]. 3D printed supports are commonly employed in industry to fix parts, both in machines and in measuring instruments.



Fig. 1. Example of a 3D printed support used to measure the shaft diameters

As for the development of the subject, along the semester, five sessions are directly related to the Manufacturing area. Session 2 consists of explaining the turning process, to the students. Session 3 corresponds to the measuring systems, both conventional and advanced, as well as the concept of tolerance interval. In session 4, the design methodology for machines is introduced. In session 5, the students design a support that will be used in session 9 to measure the diameter of the parts.

The main pedagogical approach that the teachers use in this subject is the Project Based Learning, with the final objective to perform an R&R study of the measurement system.

1.3 Objective of the research

The main objective of this work is to present the results about the application of innovative software to the subject Project I of the GETI. The purpose of applying the new software is to increase the involvement of students in the subject, and encouraging them to participate in the different activities, but mainly in the of design and manufacture of the 3D printed support.

2 METHODOLOGY

This research is included in a project called EQUIPA'T (equip yourself), in which two different schools of UPC (ESEIAAT-Terrassa School of Industrial, Aeronautics and Audiovisual Engineering and ETSEIB-Barcelona School of Industrial Engineering) are involved, as well as different departments: Projects, Mechanical Engineering, etc. The main theme of the project is the application of innovative software to the subjects involving collaborative work.

The general methodology of the EQUIPA'T project is summarized in Figure 2.

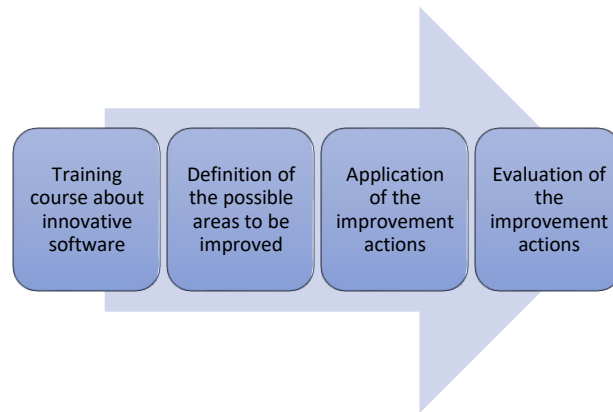


Fig. 2. General methodology of the EQUIPA'T project

The specific methodology that was used to implement the improvements to the subject Project I is explained in sections 2.1, 2.2, 2.3 and 2.4.

2.1 Initial questionnaire

During the first class, a Googleforms questionnaire was used about the different subjects that had previously been taken by the different students. It stated the following question:

Please mark what is your situation about the following subjects: 1- Statistics, 2- Statistical techniques for quality, 3- Manufacturing workshop

And the possible answers for each subject are:

1- I did not attend it, 2- I am attending it now., 3- I attended it in the past

The results of the questionnaire, which are explained in section 3.1, were used to define different subgroups among the students of each class. The idea is that in each subgroup there be, at least, one student with previous knowledge in Statistics, which will help the rest of the students in this area.

2.2 Edited videos

In order to encourage discussion in sessions 2 and 3 (about turning processes and metrology respectively), it was decided to use Edpuzzle to add questions to the videos to be presented in class. In a first step, most appropriate videos were selected among the possible ones. One video about turning operations and another video about tolerance intervals were used, which had been previously edited by other authors. The videos were shortened and more questions were added, according to the objectives and requirements of the subject Project I. The results are presented in section 3.2.

2.3 Management of the design process

The design process of the support is a quite long activity. It starts with the definition of the necessity of the technological object to be manufactured, as well as its main requirements. Then, conceptual design is carried out with the definition of the main moduli of the device. Later, the materialisation design is performed, in which different alternatives for each modulus are stated. Finally, the detail design is carried out, and

the final drawings are obtained [8]. In order to keep track of the development of the design process, the Trello software was used. It allows preparing lists of tasks in different columns: - *Pending*, - *In progress*, - *Finished*. It also allows adding drawings, pictures and comments to each task during the development of the design activity.

The results of the application of Trello to the design process of the support are presented in section 3.3.

2.4 Final questionnaire

In the final class, a Googleforms questionnaire was used in which the students were asked about 3 positive aspects of the subject and 3 aspects to be improved. The results can be found in section 3.4.

3 RESULTS

3.1 Initial questionnaire

The results about the initial questionnaire that was carried out during the first class are presented in Figure 3.

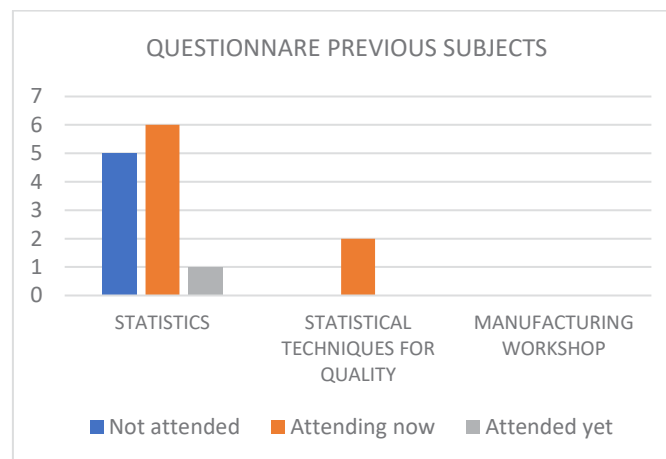


Fig. 3. Results about the subjects that the students previously attended.

Figure 3 shows that 11 students out of 12 had had previously attended Statistics or were attending it, while only 1 student had not attended the subject. In addition, 2 students were attending Statistical Techniques for Quality, and no student had previous knowledge about Manufacturing Workshop. Three different subgroups were defined in which, at least, two components had previous knowledge about Statistics.

It is expected to use the Googleforms questionnaire in the first class again the next academic years, because it helps to balance the subgroups regarding the knowledge of the students on Statistics.

3.2 Edited videos

Edpuzzle software allows the possibility to edit videos in a way that several comments and questions can be added [9,10]. In this work, two different videos were edited, for the machining (Figure 4) and for the metrology class (Figure 5) respectively. In both videos, several subsequent questions appear to be answered by the class group.

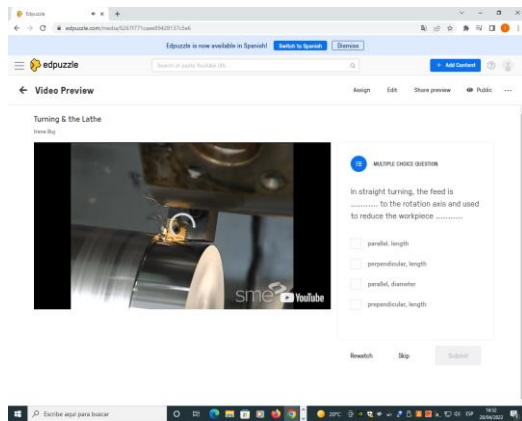


Fig.4. Screenshot of a video about turning

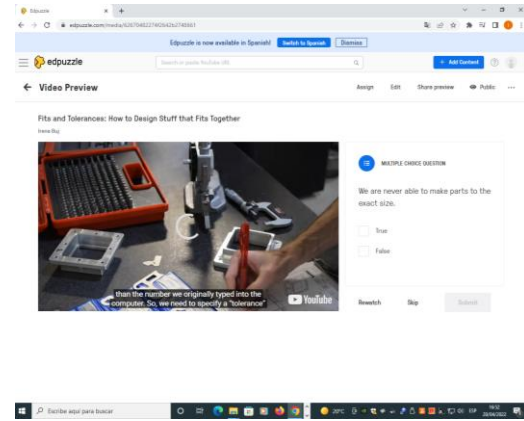


Fig. 5. Screenshot of a video about metrology

The selected video for Session 2 about machining processes is “Turning & the lathe”. In it, different turning processes are described, for example straight turning. In addition, the concept of rough and finish machining is explained.

The selected video for Session 3 about metrology is “Fits and tolerances: how to design stuff that fits together “. The concepts of nominal dimensions and tolerances are explained, as well as the three kinds of fits: clearance, transition and interference.

Both videos led to a discussion in class. For example, regarding the turning operation, the chamfering operation was commented. Its main aim is to avoid sharp edges that could hurt the person that machines or transports the part. In another example, the video about metrology helped to find some real examples for the different kind of fits that are used in mechanical design.

The next year, it is expected to add another video about 3D printing. Another possible improvement is that the students answer the questions individually, in order to analyze the results and to compare them to the final marks.

3.3 Tracking of the design process

The application of Trello led to uneven results: while some groups just used it as a list of tasks (Figure 6), other groups took great advantage of its possibilities, adding schemes, pictures and comments to the list of tasks (Figure 7).

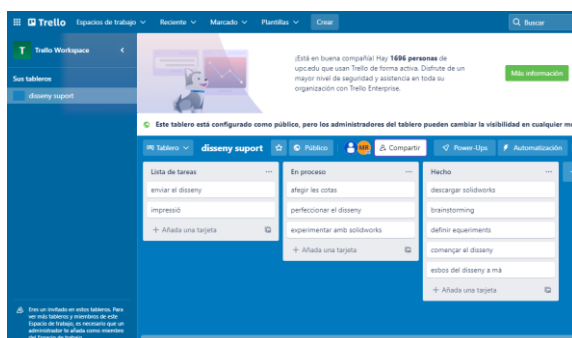


Fig. 6. Screenshot of Trello with three sets of lists

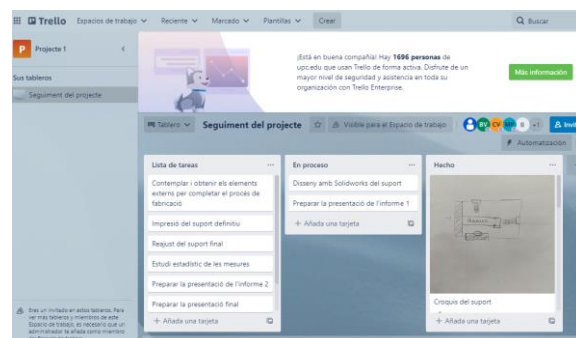


Fig. 7. Screenshot of Trello with lists and schematics

In addition, the use of Trello favoured the use of other software. For example, the Measure app of the mobile phone was used to measure the dimensions of the micrometre from an image (Figure 8).

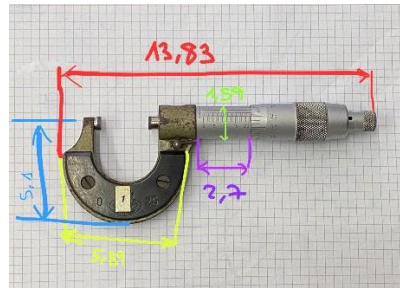


Fig. 8. Measurement of the micrometer from an image

Next year it is expected to replace the conventional written report that was used to evaluate session 5 of the subject with a Trello file, in order to avoid duplication of information.

3.4 Final questionnaire

The results of the final questionnaire are as follows (Figures 9 and 10). The most positive aspects of the subject are team work, followed by oral presentations, to learn 3D Printing and to learn Statistics. The main aspects to be improved are that there are too many presentations, the fact that all the teams deal with the same subject and the fact that there are too few laboratory classes at the workshop.

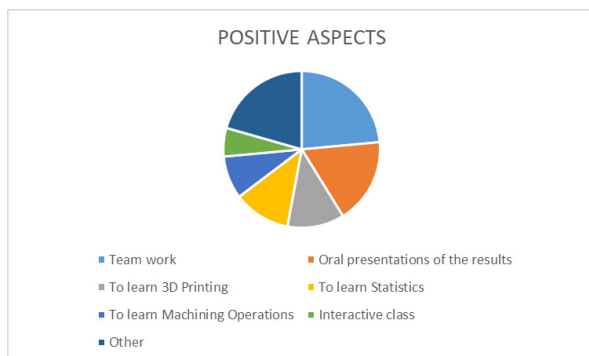


Fig. 9. Positive aspects of the subject

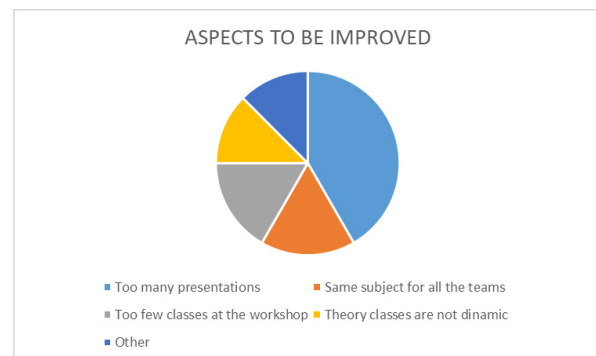


Fig. 10. Aspects to be improved

4 SUMMARY AND ACKNOWLEDGMENTS

In this work the results of the application of innovative software to the subject Project I are presented. In the first session, a Googleforms questionnaire was used to ask the students which subjects they have previously taken. In the second and third sessions, Eddpuzzle was used to add questions to a video, which were answered by the students globally in class. In the fourth and fifth class, the tool Trello was used, which allows to perform a list of tasks that are pending, in process and finished respectively. In the last class, the students were asked about the subject with another questionnaire. From the teacher's standpoint, all the innovative tools allowed to enhance the discussion of the subject with the students in class.



In subsequent academic years, it is expected to use the three tools again, with a special focus on the possibilities of Trello, which could completely substitute the use of conventional reports along the design process of the measuring supports. The students mainly appreciate team work and the possibility to present their achievements.

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REFERENCES

- [1] M.G. Morrow, C.H.G. Wright, T.B. Welch, Old tricks for a new dog: An innovative software tool for teaching real-time DSP on a new hardware platform, *Comput. Educ. J.* 21 (2011) 64–69. <https://doi.org/10.18260/1-2--18418>.
- [2] M. Cyr, V. Miragila, T. Nocera, C. Rogers, Low-cost, innovative methodology for teaching engineering through experimentation, *J. Eng. Educ.* 86 (1997) 167–171. <https://doi.org/10.1002/j.2168-9830.1997.tb00280.x>.
- [3] L. Johns-Boast, S. Flint, Simulating industry: An innovative software engineering capstone design course, *Proc. - Front. Educ. Conf. FIE.* (2013) 1782–1788. <https://doi.org/10.1109/FIE.2013.6685145>.
- [4] D. González-Morales, L.M. Moreno De Antonio, J.L. Roda Garcia, Teaching “soft” skills in Software Engineering, 2011 IEEE Glob. Eng. Educ. Conf. EDUCON 2011. (2011) 630–637. <https://doi.org/10.1109/EDUCON.2011.5773204>.
- [5] I. Buj-Corral, L. Marco-Almagro, A. Riba, J. Vivancos-Calvet, X. Tort-Martorell, Avaluació de l'ensenyament basat en projectes en l'àrea de la fabricació i l'estadística en el grau de tecnologies industrials, in: CIDUI2014, 2014.
- [6] I. Buj-Corral, L. Marco-Almagro, A. Riba, J. Vivancos-Calvet, X. Tort-Martorell, Evaluation of project based learning in the area of manufacturing and statistics in the degree of industrial technology, *J. Technol. Sci. Educ.* 5 (2015). <https://doi.org/10.3926/jotse.150>.
- [7] I. Buj-Corral, E.E. Zayas F, L. Marco-Almagro, L. Roderó, Proyecto I: Estudio del sistema de medición de diámetros de ejes vinculando disciplinas diversas, in: *Actas Del XXII Congr. Nac. Ing. Mecánica*, 2021.
- [8] C. Riba-Romeva, *Disseny de màquines. V Metodologia*, 2002.
- [9] R. Asrofin, A. Efendi, D. Ardianto, Edpuzzle-Based Blended Learning Model for Mechanic Engineering Learning to Improve Student Critical Thinking Skills in Vocational Schools, (2020). <https://doi.org/10.4108/eai.2-11-2019.2294782>.
- [10] G. Giyanto, L. Heliawaty, B. Rubini, The effectiveness of online learning by EdPuzzle in polymer materials on students' problem-solving skills, *IOP Conf. Ser. Mater. Sci. Eng.* 959 (2020). <https://doi.org/10.1088/1757-899X/959/1/012006>.