Creation of a virtual museum as a learning tool in the teaching of the Manufacturing Engineering subject

M J Martín[1*], F Martín[2] and M J Cano[3]

[1, 2, 3] Department of Civil, Materials and Manufacturing Engineering, University of Malaga. Dr. Ortiz Ramos Street, 29071, Málaga, Spain.

*Corresponding author: mjmartin@uma.es

Abstract: Teaching subjects such as Manufacturing Engineering requires the use of effective teaching tools, which help students in their learning process. While the traditional transmission model can be effective when teaching concepts and theoretical contents, others activities are essential to allow students to participate, act or reflect, thus developing skills and competences, such us communication, teamwork, and creativity. This paper presents a learning tool based on the creation of a virtual museum related to the Manufacturing Engineering field, which is included as a coursework in the teaching program of the subject "Manufacturing Engineering". This subject is taught at the second year of different degrees at the Industrial Engineering School of the University of Malaga and a percentage of its final grade comes from this activity. The museum is materialized through the posters whose format is similar to those presented at conferences and whose content may be referred to three topics (object, process or biography). Once the students are given the necessary instructions, each project is selected by a work group and its development is supervised in the next two sessions by the lecturer. In the final stage, each group give the presentation about their work. The analysis of the students' grades obtained from both this activity and the whole subject makes it possible to quantify the impact of this type of activities on the student learning and achievement. Eventually, best posters will be part of the department collection, being accessible to students in subsequent years.

Keywords: Learning tools, Manufacturing engineering, Virtual museum, Active methodologies, ICTs technologies.

1.   Introduction

Traditionally, the mostly used teaching methods at university has been the transmission model where an expert on a discipline transmit information to learners who must store and work on it. However, the new educational trends make the emphasis on using innovative teaching practices which enable actives and collaborative methodologies in which students participate dynamically in their learning process [1– 6]. Also, this transformation has been strongly reinforced by the Information and Communication Technologies (ICTs) [7–10], making this combination between active technologies and ICT tools an excellent educational strategy to improve both the teaching process and the learning performance [11]. In particular, in the Industrial Engineering degrees it is absolutely indispensable to define an adequate structure of teaching tools that allows students to achieve a significant number of essential competencies for the professional career of the future engineer [12]. For this reason, in addition to the already traditional teaching by means of class and solving problems sessions or practical laboratory sessions is necessary the implementation of activities aimed to engage the student in their personal study and in the

collaborative working [13]. Consequently, it is crucial that the integration of the different activities enables it to accomplish the complete learning process, not only in terms of knowledge but also with regards to the skills development [12]. In this context, the generation of a virtual museum related to the manufacturing field is part of the set of activities that constitutes the teaching structure of this subject at the Industrial Engineering School of Malaga University. This activity is intended to be done by groups and is supposed to promote the collaborative work among students [14]. Each project is materialized by a poster, following a format similar to that required for a contribution to Conferences. The versatility and visual impact of a poster make it a useful medium of communication identifying easily the focus of interest. Doing this coursework, students can also develop their skill to synthesize and organize information in a small space and to show the information in a visually appealing to the reader. In the end, working on different types of documentary sources, organizing the information, developing the documents and presenting them will increase their learning performance.

2. Methodology

The didactic resource presented has focused on the development of a virtual museum in the field of Manufacturing Engineering. This coursework is materialized as a poster to facilitate quick visual comprehension. It was developed through the academic years 2017/2018 and 2018/2019 and took part 1037 students from the Manufacturing Engineering subject that is taught in the second year of 5 degrees at the Industrial Engineering School of the Malaga University.

The information to be considered in the posters is classified by three categories:

- Manufacturing processes included in the teaching program of the subject
- Everyday objects manufacturing processes
- Biography of relevant scientists and engineers (especially female contributions)

The project has been carried out in three stages:

2.1. Stage 1.- Activity design

Lecturers involved in the experience discussed and decided about the configuration of this teaching resource, analyzing the study groups, the ICT tools, and the different options to be proposed (manufacturing process, object, and biography). Formats, tasks and schedule as well as the evaluation items will be defined. Eventually, is established that carrying out this activity is voluntary for the students and it is worth 10 percent of the total grade (maximum 1 point out of 10 points).

2.2. Stage 2.- Experience development

The activity is carried out along the first semester when the number of student involved in this subject is the greater. Five sessions are planned (1.5 hours per session): one at the beginning of the activity, two intermediate sessions during its development and two final sessions where the students present their poster (figure 1).
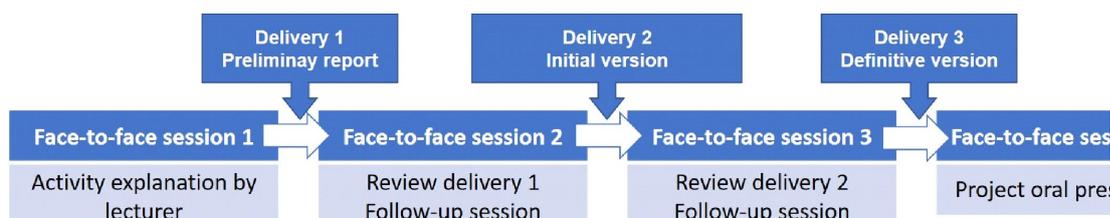
Figure 1. Activity schedule.

In session 1, teachers clearly express the expectations of the assignment and explaining what students have to do, how they have to do it and how they have to make the poster presentation. Special attention is paid to describe the structure of the posters, including the compulsory sections to complete (figure 2):

- Design, materials, manufacturing processes and quality control
- Manufacturing process stages, graphic diagram, materials and alternative processes
- Biographic data from the scientist selected, contributions and descriptive images

Instructions are uploaded onto the virtual campus platform (VC) so that they can refer to them as they work. Afterwards, students form the working group (4 students per group) and choose their project from the list proposed. Before session 2, each group have to submit to VC a preliminary summary with the main lines of their work as well as the documentary resource selected.

In session 2, tutors review the preliminary summary with student clarifying any confusing points and providing students with feedback that can help them comprehend and complete the task. In this point each group hand in an initial version of the poster for revision.

Figure 2. Posters typology: **(a)** Product. **(b)** Process. **(c)** Biography.

Session 3 centers on finishing off the project, which will be submitted to VC, meeting the deadline. In the last two sessions each group present their project (a maximum of 15 minutes), describing the most important contents from the poster. The tutor and classmates can make questions and discuss about aspect that need to be clarified. One of the most important objectives of this part is evaluate the capacity of the working group to define, structure and present the results of their project. Also, the rest of student receive additional information related to the subject topics being able to do their own assessment and, therefore, increasing their learning performance.

2.3.   Stage 3..- Experience assessment

Once finished and presented the assignment each working group is evaluated by the responsible tutor and providing a strong and detailed evaluating rubric can make the teacher's job clearer, easier and more solid. The rubric is specifically customized for this project and includes three assessment levels with different sections which address the criteria of the outcomes to be measured. Also, it is necessary to ensure that the rubric is applied consistently by the different users which depends on how well the criteria and the scale points are defined. For this reason, responsible lecturers work in a session sharing and adjusting the criteria, scales and descriptors. Each tutor completed a rubric per project, assigning the same score to the whole group. The three level of evaluation are:

- Classroom participation: attendance at face-to-face classes, delivery before the due date and attendance performance.

- Poster quality: difficulty level, preliminary report quality, structure, bibliographic information resources, illustrations (within the general aspects considered). Also, specific information related to the category selected is evaluated.
- Quality of the class presentation: comprehensibility and coherence of the content, design of the slides, clarity of voice projection, ability to communicate clearly, presentation within the allotted time frame, accuracy of the answers to questions formulated after presentation.

In addition, once the evaluation process is concluded, students had the opportunity to express their satisfaction level with the activity performed through completing an online survey. Obviously, this is an optional and anonymous activity. The questionnaire includes 10 questions and answers are configured on a scale from 1 to 10 (1 minimum score, 10 maximum score):

1. This kind of activity is innovative
2. The terms proposed are interesting
3. The members of the workgroup has been involved proportionally
4. The lecturers have adequately explained the objectives of the work proposed
5. The follow-up sessions have been enough to achieve the objectives
6. The lecturers have resolved satisfactorily the doubts during the development of the coursework
7. There has been enough time to finish this activity adequately
8. The grade assigned this work regarding to the global grade of the subject (10%) is reasonable
9. Carrying out the work has made me easier learn the subject
10. General opinion about this activity

3. Results

Results from this work are analysed under a double point of view. On the one hand, the influence of the activity on the final grade of the student in the subject evaluated; on the other hand, the suitability of this activity as a teaching and learning resource in the development of the subject, obtained from the answers of the students' surveys.

The first phase, considering a period of two years, the participation level of the students in the experience has been evaluated. As shown figure 3 (a) and 3 b), the participation of students as a whole, by degrees, reflects an increase in all of them between the two years studied, ranging the incremental variation between the 1.65% in the GIEI degree and the 22.63% in the GIE degree. The incremental average is higher than 11.64%, increasing from a mean participation of 69.18% in the 2017-2018 academic year to 80.83% in 2018-2019 (table 1).
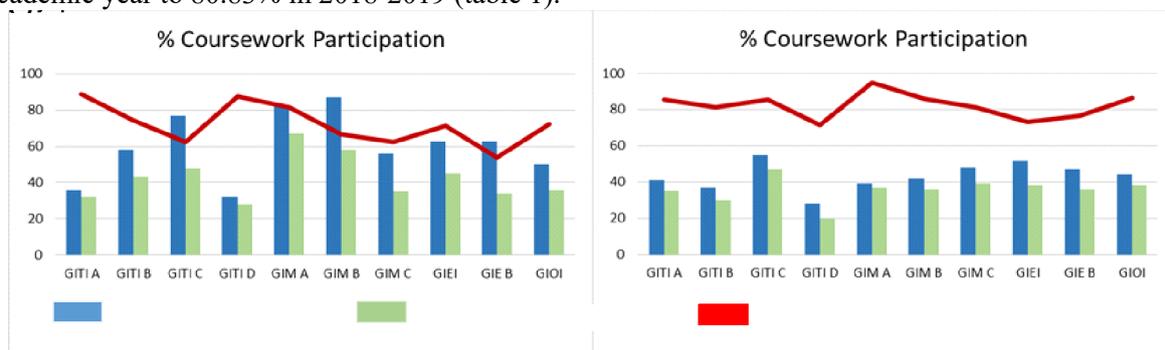

Figure 3. Participation percentage by degree and academic year: **(a)** 2017-2018 **(b)** 2018-2019.

Table 1. Participation percentages.

Degree	Participation 17/18 (%)	Participation 18/19 (%)	Variation of participation (%)
Industrial Technologies (GITI)	78.22	80.83	2.61
Industrial Mechanic (GIM)	70.29	87.27	16.98
Industrial Electronic (GIEI)	71.43	73.08	1.65
Industrial Electric (GIE)	53.97	76.60	22.63
Industrial Organization (GIOI)	72.00	86.36	14.36

The influence of carrying out this activity is reflected in table 2 and figure 4. Table 2 shows the mean grades of the subject and the coursework mean grades per degree and group in 2018-19.

Table 2. Average grades of degree and coursework. Variation percentage (academic year 2018/2019).

Degree and Group	Subject mean grades	Work mean grades	Variation (%)
GITI A	6.53	8.81	34.92
GITI B	5.84	7.84	34.24
GITI C	6.29	7.56	20.19
GITI D	7.11	8.64	21.52
GIM A	6.62	8.13	22.81
GIM B	6.20	8.11	30.81
GIM C	6.10	8.83	44.75
GIEI	5.70	7.92	38.95
GIE B	4.82	7.61	57.88
GIOI	5.38	8.68	61.34
Mean	**6.06**	**8.21**	**35.48**

Figure 4 shows the positive results of the coursework. The graph on the right increases the sensitivity, showing the grades range from 7 to 9.
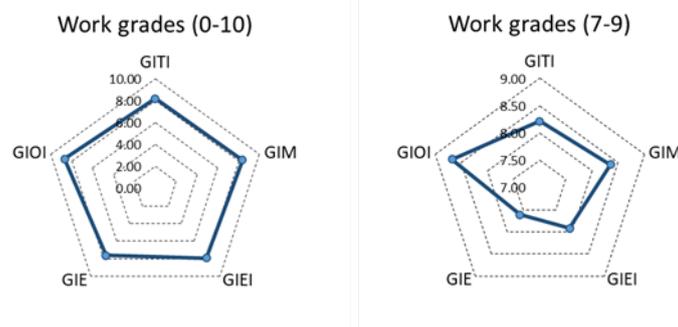

Figure 4. Coursework grades (academic year 2018/2019).

The overall grade of the coursework is significantly higher than the final grade of the subject, being of up to 61.34% the increase in the GIOI degree compared to the 27.72% of the GITI degree, considering that both cases present a significant increase. As an example, figure 5 presents results from the GITI degree; group C; 2017-2018. It is seen as the students who did not do the activity (non-compulsory) obtained grades in a significantly lower range (yellow) than the students carrying out the project (grey). In addition, the overall grade of the subject (orange) is significantly improved because of the positive outcome of the activity.
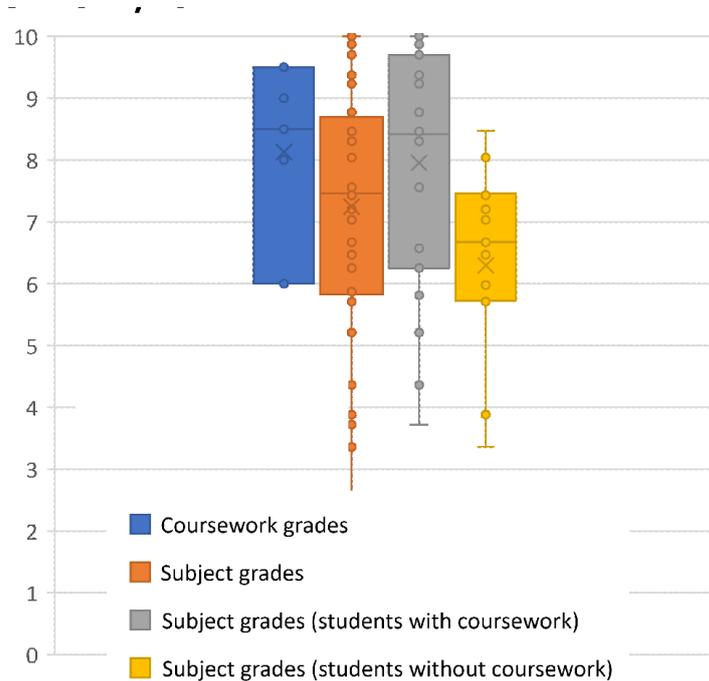
Figure 5. Grades range in GITI degree, group C (academic year 2017/2018).

Once analysed the grades from the coursework and the overall grades of the different degrees, groups and academic years, table 3 and figure 6 identify the results from the surveys completed by students from the GITI B, GIEI, GIE B and GIM A, including the mean value.

Table 3. Results from GITI B, GIEI, GIE B and GIM A surveys and mean values.

| Question number	Question	GITI B	GIEI	GIE B	GIM A	Mean
1	This kind of activity is innovative	7.47	7.68	6.80	7.52	**7.37**
2	The terms proposed are interesting	8.53	7.95	7.60	8.00	**8.02**
3	The members of the workgroup …	8.68	8.42	7.2	8.91	**8.30**
4	The lecturers have adequately …..	8.95	8.79	8.8	8.43	**8.74**
5	The follow-up sessions …	8.95	8.58	9	8.13	**8.67**
6	The lecturers have resolved ..	9.26	8.84	9.4	8.70	**9.05**
7	There has been enough time …	9.21	8.68	9.2	9.13	**9.05**
8	The grade assigned ….	7.89	7.53	7.8	7.91	**7.78**
9	Carrying out the work..	7.42	7.16	6.6	6.91	**7.02**
10	General opinion ..	8.47	8.32	8.2	7.91	**8.22**
	Mean	**8.48**	**8.2**	**8.06**	**8.16**	**8.22**
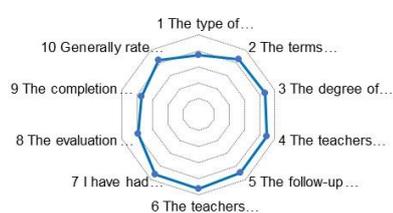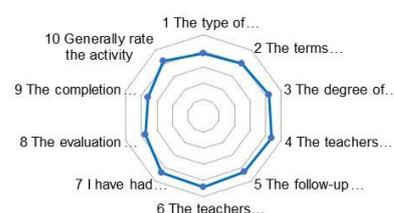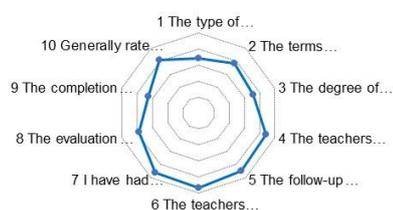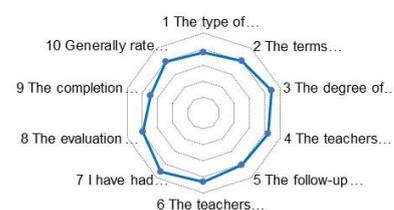
Figure 6. Surveys results (by degree groups).

4. Conclusions

Data exposed in the previous section allow us to evaluate this experience under quantitative and qualitative approaches. From an objective point of view, results from the participation level and grades of the students show that being already very significant the initial interest of student in doing this activity (70.53% student in 2017/2018), the participation rate rose up to 82.22% in 2018/2019. This increase is not only presented in the joint analysis but in each and every one degrees and groups studied. Consequently, it is confirmed that doing the coursework received an excellent approval from the student.

Another key conclusion is established based on the highly satisfactory influence that the coursework grade had had on the overall subject grade. In the 2018/2019 academic year, the grades range was from 7.56 to 8.83, depending on the group and degree. The higher score of this activity regarding to the rest of activities developed in the subject (27.48 % al 61.34 % depending on group) show the interest and engagement of the students in developing this coursework.

From a subjective point of view, taking into account the anonymous surveys where students indicated their level of satisfaction with the activity developed, results provide an undeniable evidence that the students who decided to do this activity resulted extremely satisfied with it, assigning a global score of 8.22 out of 10 in their evaluation.

Eventually, analysing elaborately the feedback received from student surveys, questions responses present values in decreasing order and grouped according to affinity of concepts, as listed below:

Explanation, following-up and clarification of doubts by the tutor responsible of the activity (questions 4 and 6 with 8.74 and 9.05 grades respectively); procedural items such as submissions deadline, follow-up sessions and so on (questions 5 and 7 scored 8.67 and 9.05 respectively); transversal competencies in collaborative work (question 3, scored 8.3); general opinion about the activity (question 10, with score 8.22). This last one is identical to those mean value obtained from the whole set of questions include in the questionnaire, which is a clear example of the rigor in which the questions are answered; questions related to the weight of the assignment out of the final subject grade (questions 2 and 8, scored 8.02 and 7.78 respectively); innovative characteristic of the activity (question 1, scored 7.37); tenth question regarding the learning process of the subject (question 9, score of 7.02).

In conclusion, the fact that every score is above 70% demonstrates the positive consequence of using this type of activity in the teaching plan of the subject, reaching essential objectives such as: researching initiation, transversal competencies, collaborative work, project design or managing of a second languages.

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