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APPLYING RUBRICS IN GRAPHICAL EXPRESSION SUBJECT IN ENGINEERING DEGREES

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The subject of Graphical Expression at Universitat Jaume I presents a structure where the acquired knowledge accumulates progressively. For this reason, the correction criteria for continuous assessment tests evolve accordingly along the academic course. In order to make students aware of these criteria, subject's teachers provided them rubrics created in accordance to these criteria. These rubrics were intended to promote student's autonomous learning and to provide a tool for them when studying for the exams. An online rubrics application workshop was organised in order to familiarize students with rubrics before the exam. After analysing the exam scores it was observed that those students that participated in the workshop obtained higher scores than those who did not, and also higher than scores obtained the past academic course. Furthermore, students and teachers were asked to answer a questionnaire regarding their perception towards rubrics implantation and the workshop, and both collectives gave very positive feedback. These results encourage subject's teachers to go forward providing rubrics and organising application workshops.

Keywords: graphic engineering; technical drawing; rubrics

IMPLANTACIÓN DE RÚBRICAS EN LA ASIGNATURA DE EXPRESIÓN GRÁFICA EN LOS GRADOS DE INGENIERÍA

La asignatura de Expresión Gráfica en la Universitat Jaume I presenta una estructura en la que los conocimientos adquiridos se acumulan progresivamente. Por dicho motivo, los criterios de corrección de las pruebas de evaluación continua siguen una evolución acorde a lo largo del curso. Con el fin de hacer conocedores a los alumnos de estos criterios, el profesorado de la asignatura planteó la redacción de unas rúbricas para el alumnado acordes a dichos criterios. Con éstas se pretendía mejorar el aprendizaje autónomo del alumno y facilitarle la preparación de las pruebas. Para familiarizar al alumnado con las rúbricas antes del examen se realizó un taller online de aplicación de las mismas. Tras realizar el examen se analizaron las notas, obteniendo que aquellos alumnos que participaron en el taller tenían notas más altas que las de aquellos que no participaron en el taller y más altas que las obtenidas en el curso anterior. Además, se realizó una encuesta a profesores y alumnos para estudiar la percepción de la implantación de rúbricas y el taller, en la que ambos colectivos valoraron muy positivamente la iniciativa. Estos resultados animan a los profesores de la asignatura a continuar en dicha línea de trabajo.

Palabras clave: ingeniería gráfica; dibujo técnico; rúbricas

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1. Introduction

The subject of Graphical Expression at Universitat Jaume I has recently experienced considerable modifications, owing to the constant evolution that is experiencing teaching in Technical Drawing towards new paradigms based on 3D modelling. During last academic courses a methodological change was introduced, in order to improve students' spatial vision skills. These changes were based in the idea of start from modelling in 3D to get the orthographic projections or the axonometric views so that they can then go the reverse way (from views to the 3D model) more easily (Pérez-Belis et al., 2015). Furthermore, aiming for a more intuitive introduction to 3D modelling, in the last course, the use of a specific commercial parametric CAD (SolidWorks) was introduced (Roda- Sales et al., 2019), replacing the non-parametric CAD tool used previously in the subject (AutoCAD).

This subject is composed of a theoretical part and a practical part, which are taught in different lessons but are correlated throughout the academic course. Graphical Expression presents a structure where the acquired knowledge accumulates progressively, starting with 3D modelling of parts, followed by the generation of their technical drawings, the creation of assemblies using these parts and, finally, the generation of assembly technical drawings. The assessment of the skills is performed via two partial exams (the first one assessing modelling and the second one assessing modelling and technical drawings) and a final exam (which also includes, apart from those contents, the assemblies and their technical drawings). For this reason, the correction criteria for continuous assessment tests evolve accordingly along the academic course, and the different evaluated contents have a proportional score as new ones are introduced. Last course different material was provided to the students to promote their self-learning so that student became the centre in their learning experience as constructivism promotes (Gómez-Granell and Coll Salvador, 1994) creating their own knowledge (Zaphiris and Ioannou, 2014). Notwithstanding, the students need to know how their progress is going to be evaluated (Sanmartí, 2007). Strategic knowledge is ingrained in 3D modelling (Diwakaran and Johnson, 2012; Garikano et al., 2019) and several studies analyse how quality in modelling must be assessed through their reusability (Camba et al., 2016) or how to assess assemblies (Otey et al., 2019). Previous experiences in other subjects (Gracia-Ibáñez et al., 2018) with rubrics or even in the same subject but before the important changes undertaken (Pérez-Belis et al., 2016) led us to understand that students needed to have rubrics at disposal. Apart from creating these rubrics, a workshop Moodle was planned out so that students could practice previous to the exam, the modelling of a part from an exam of the previous year where they could apply the rubric by means of evaluating themselves and evaluating a colleague (Gracia-Ibáñez et al., 2018).

To analyse the impact of the novelties from a holistic point of view, the teachers became teachers-researchers (Rudduck and Hopkins, 1985) proposing an action-research (Gracia-Ibáñez et al., 2014; Gracia-Ibáñez and Vergara, 2016) where the perception of both students and teachers are taken into account along with the comparison of the academic results through marks comparison.

2. Objectives

The main objective of this work is to create rubrics for the correction of the first partial exam (henceforth exam) in order to make students aware of the correction criteria. These rubrics are intended to promote student's autonomous learning and to be a tool for them when studying. In order to familiarize students with the rubrics before the final test, teachers organized a non-compulsory rubrics application workshop Moodle. This workshop was intended to be an activity to simulate the exam. Thus, in order to make students aware about

the required level, the part to be modelled in the workshop Moodle was the one corresponding to the past course exam.

In order to assess the benefit of introducing rubrics and organizing the workshop Moodle, both students and teachers were asked to answer a specific questionnaire regarding their perception towards it. Furthermore, scores obtained in the exam were compared with those obtained the past course.

3. Methodology

3.1 Creation of rubrics

Even though Graphical Expression is a subject with 9 teachers implied, an agreement was achieved regarding the aspects assessed in the rubrics for the modelling exam. These rubrics were based on the correction criteria applied in the past course exam, but adding some modifications that teachers considered that would improve this year's correction process. The main structure divided the rubrics in two main parts: modelling the part (P1) and modifying the part (P2).

As P1 (with a weight of 80% of the total score) was intended to assess the modelling process, it was subdivided in several sections, as 3D models are commonly composed of several subparts. These subparts or features are classified in three different types: basic features (A type), specific features (B type) and feature patterns/mirroring (C type). The scoring method for each feature type is detailed in the rubrics.

The scoring method varies depending on the feature type, and full score is obtained when this feature is correctly generated. For A type (extrude, extruded cut, revolve, revolved cut, loft and lofted cut, sweep and swept cut) full score is obtained when the feature is generated using the correct feature command, all the dimensional/geometric constraints in the sketches are correct and all the feature parameters are so. For B type (fillet, hole wizard, rib, etc.) full score is obtained when the feature is generated using the specific feature command, all the dimensional/geometric constraints in the sketches (both in drill positioning, drill dimensions and rib position) are correct and all the feature parameters are so (drill characteristics, fillet dimensions and rib dimensions). Finally, for C type (feature patterns, mirroring, etc.) full score is obtained when the pattern or mirroring is generated using the specific command and all the parameters are correct (symmetry plane, number of features to replicate in patterns, etc.).

Apart from this, P1 had other sections taking into account other modelling aspects, such as renaming the operations of the model tree or orienting properly the part regarding the global reference system. Table 1 presents an overview of the main structure of this part.

P2 (with a weight of 20%) assessed the modifications they were asked to perform to the part once modelled. These modifications in CAD models are known as configurations, in which the model is modified to perform design variations (dimensions, features, properties, etc.) and can be saved in the same document. As they are first-year students, they only were asked to generate two configurations: the first one with the same dimensions as the modelled in P1 and the second one with small alterations normally referred to sketch dimensions or operation parameters that could be easily modified. The weight of each modification in the final score was proportional to the number of modifications they were asked to perform.

Table 1: Overview of the aspects assessed in P1.

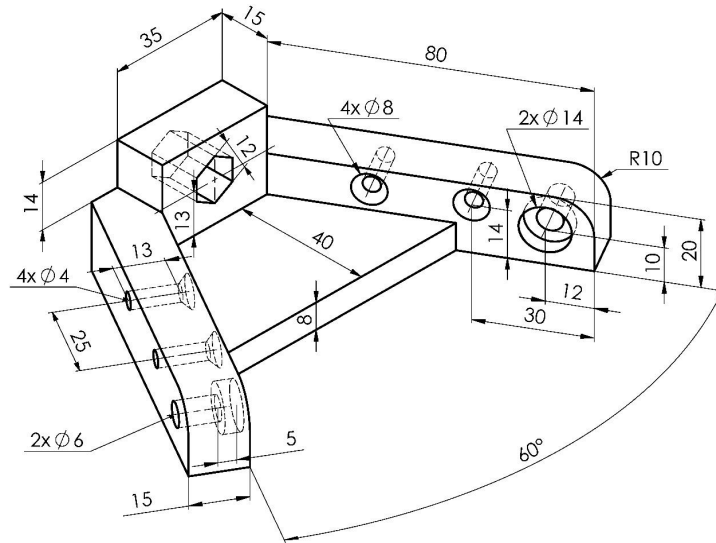|	Aspect
1.0	Validity: The file can be correctly opened with SolidWorks.
1.1A	A type features: Basic features (extrude, extruded cut, revolve, revolved cut, loft, lofted cut, sweep and swept cut). - Feature correctly generated using the correct command. - Dimensional/geometric restrictions are correct in sketches. - Feature parameters are correct (dimensions, surfaces, etc.).
1.1B	B type features: Specific features (fillet, hole wizard, rib, etc.) - Hole wizard was used to add a drill. - Specific fillet command was used to do so. - Drills are correctly located. - Drill dimensions are correct. - Fillet/rib parameters are correct.
1.1C	C type features: Feature patterns, mirroring, etc. - Specific commands to perform patterns were used or mirroring was applied when part was symmetric. - Pattern/mirror parameters are correct.
1.2	Part orientation is correct regarding the global reference system.
1.3	The different sections of the design tree are renamed.

3.2 Rubrics application workshop Moodle

Students were introduced to the new rubrics in their respective practical lessons. Then, teachers presented the online workshop Moodle so that they could apply the rubrics. Students were initially informed that the workshop Moodle was not compulsory and it would not have any effect in their final scores. They were said that it was only intended to be a tool for them in order to prepare their modelling exam and improve their modelling.

This workshop consisted, firstly, in modelling the part proposed in the past course exam. They were given one week to submit the file with their proposed solution. The material they had available were the rubrics and the dimensions of the part to be modelled (Figure 1).

After this, they had another week to assess their own work and one from a classmate's randomly assigned via an online assessment method that teachers had previously configured. Students assessed the works following the rubrics criterion and assigning each subpart of the fig.1 their corresponding weighting. In each section they were asked to assess each feature or aspect to obtain the final score. Additionally, students had also specific criteria on how penalize each type of error made.

Figure 1: Part to be modelled in the rubrics application workshop Moodle.

3.3 Students' questionnaire

After obtaining the scores of the exam, students were asked to answer a specific anonymous questionnaire, in order to assess their perception regarding the rubrics application workshop Moodle. They signed electronically a data protection agreement. This document showed the questionnaire's purpose and explained that teachers assure confidentiality and protect the personal data handled. After this, they were asked about certain basic aspects: their degree, whether they were repeating course, their level of attendance to the practical lessons or their participation in the workshop. Then, they were asked different questions depending on whether they had participated (table 3) or not (table 2) but with three common questions referred to having exam from last year to practise as well as the rubric at disposal (S3 to S5). In case they did not participate in the workshop, they were asked about the reasons (Table 2, S6n).

Table 2. Questions asked to the students that did not participate in the rubrics application workshop Moodle.

ID	Question
S1n	Did you know that the part to be modelled corresponded to the one proposed in the past course exam? (Yes/No)
S2n	Did you know that the rubrics applied in the workshop Moodle corresponded to the exam correction criteria? (Yes/No)
S3n	Having the part proposed in the past course exam was useful to study for the exam. (1-5 Likert scale)
S4n	Rubrics were useful to study for the exam. (1-5 Likert scale)
S5n	Rubrics made me aware of certain aspects to take into account when modelling. (1-5 Likert scale)
S6n	Did you not participate in the workshop Moodle because you were not aware of the methods? Or it was your own decision? (Not aware/Own decision)

Table 3. Questions asked to the students that participated in the rubrics application workshop Moodle.

ID	Question
S1y	Self-assessment was useful to detect my weaknesses when modelling. (1-5 Likert scale)
S2y	Assessing a classmate helped me to see the errors that I should avoid. (1-5 Likert scale)
S3y	Having the part proposed in the past course exam was useful to study for the exam. (1-5 Likert scale)
S4y	Rubrics were useful when studying for the exam. (1-5 Likert scale)
S5y	Rubrics made me aware of certain aspects to take into account when modelling. (1-5 Likert scale)
S6y	Overall, the workshop Moodle was a useful learning tool, it helped me to study for the exam. (1-5 Likert scale)

Descriptive analyses were performed after collecting all the answers. Furthermore, ANOVAs were applied to check if the rating given by students in common questions S3, S4 and S5 was significantly different between those students that participated in the workshop and those who did not.

3.4 Teachers' questionnaire

After correcting the exams, all the teachers of the subject were asked to answer a specific anonymous questionnaire about their perception regarding the rubrics application workshop. They were asked about certain basic aspects, as the years they taught the subject or whether they taught it the past course. Furthermore, they were asked about the questions detailed in Table 4. After collecting all the answers, descriptive analyses were performed.

Table 4. Questions to get teachers' perception.

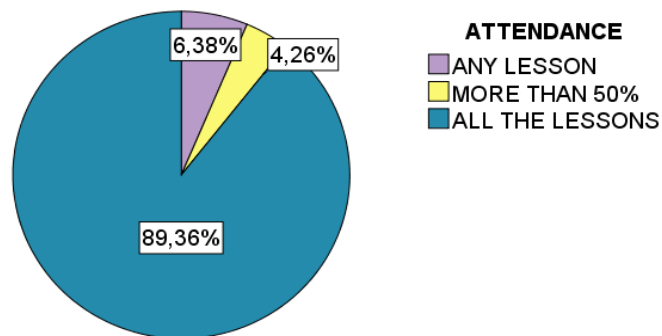| ID	Question
T1	Having the part proposed in the past course exam may have been useful for the students to study for the exam. (1-5 Likert scale)
T2	Rubrics may have been useful for the students when studying for the exam. (1-5 Likert scale)
T3	Rubrics made them aware of certain aspects to take into account when modelling. (1-5 Likert scale)

3.5 Scores comparison

In order to assess the effect of using the rubric and the Moodle workshop, two comparisons of scores were made: between groups of students who participated or not in the workshop, and between the students who participated in the workshop and the scores obtained by students in last year. To do so, scores of both parts of the exam (P1 and P2) and final scores (which took into account both parts) were normalized over 10. After this, descriptive analyses were performed. ANOVAs were applied for final scores, taking, firstly, the participation in the workshop as a factor. After this, the academic course was taken as factor, in order to check if scores were significantly different between courses.

4. Results

4.1 Students' questionnaire results

From the 289 students enrolled in the subject, 87 decided to participate in the Moodle workshop (what implied a participation of 30.10%). A total of 47 students answered the questionnaire (10.6% from Electrical Engineering, 25.5% from Mechanical Engineering, 29.8% from Chemical Engineering and 34% from Industrial Technologies Engineering) and from those, 63.8% participated in the workshop Moodle. The level of attendance to the practical lessons that they reported is presented in Figure 3:

Figure 3: Reported level of attendance to the practical lessons.

When the students that answered the questionnaire but did not participate in the workshop were asked about the reasons (question S6n), 58.8% said that they were not aware of the workshop methodology, while the 41.2% answered that it was their own decision not to participate. From those students that did not participate, 52.9% was aware that the activity consisted in modelling the part corresponding to the past course exam (question S1n), and 58.8% knew that the rubrics used in the workshop corresponded to the exam correction criteria (question S2n).

The students that answered the questionnaire and participated in the workshop gave a mean rating of (M = 3.4, SD = 1.28) out of 5 in a Likert scale the aspect assessed in the S1y (if self-assessment was useful to detect their weaknesses when modelling) and a mean rating of (M = 2.93, SD=1.11) out of 5 the aspect assessed in S2y (if assessing a classmate was useful to see the errors that they should avoid). These same students gave a mean rating of (M = 3.73, SD = 1.17) out of 5 when they were asked if the workshop Moodle was a useful learning tool and helped them to study for the exam (S6y). Figure 4 shows a box and whiskers plot of the ratings given to these aspects.

Figure 4: Ratings given to the aspects assessed in S1y, S2y and S6y.
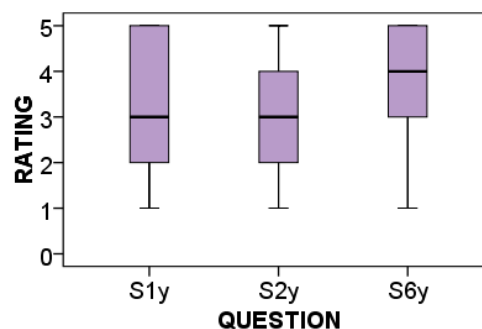
When all the students (both those who participated in the workshop and those who did not) were asked to rate the aspect S3 (if having the part proposed in the past course exam was useful to study for the exam), they gave a mean rating of (M = 3.92, SD = 1.06) out of 5. When assessing the aspect S4 (if rubrics were useful when studying for the exam) they gave a mean rating of (M = 3.65, SD = 1.03) out of 5. Finally, when rating the aspect in S5 (if rubrics made them aware of certain aspects to take into account when modelling) they gave a mean rating of (M = 3.85, SD = 0.95) out of 5. Figure 5 shows a box and whiskers plot of the ratings given to these aspects, but separated depending on their participation in the workshop.

Figure 5: Ratings given to the aspects assessed in S3, S4 and S5, depending of their participation in the rubrics application workshop Moodle.
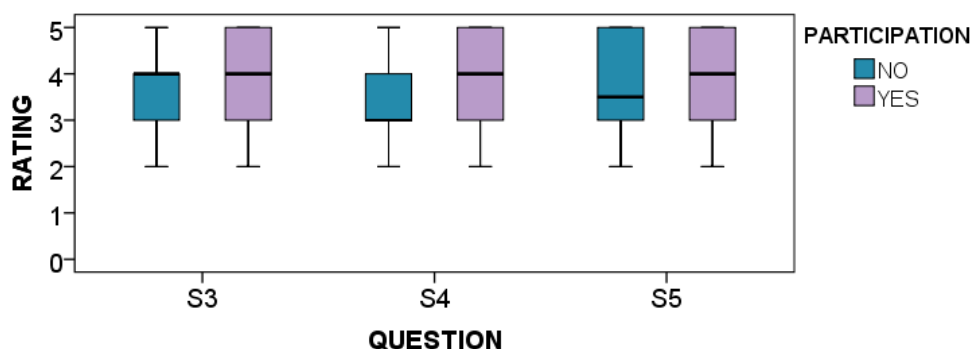
After performing an ANOVA for the rating obtained in each question, taking the participation as factor, and the mean rating in each case as dependent variable, they were found not to be significantly different (Sig.≤0.05).

4.2 Teachers' questionnaire results

The nine teachers of the subject answered the specific questionnaire. From those teachers, 66.7% taught the subject the past course. Regarding the years teaching the subject, 11.1% have taught the subject only one year, 22.2% between 2 and 5 years, 55.6% between 5 and 10 years and 11.1% taught it more than 10 years. When they were asked to assess the aspect in T1 (if having the part proposed in the past course exam may have been useful for the students to study for the exam) they gave a mean rating of (M = 4.11, SD = 0.60) out of 5. When assessing the aspect in T2 (if rubrics may have been useful for the students when studying for the exam) they gave a mean rating of (M = 4.22, SD = 0.67) out of five. Finally, when they were asked to assess the aspect in T3 (if rubrics made students aware of certain aspects to take into account when modelling) they gave a mean rating of (M = 4.11, SD = 0.78) out of 5.

4.3 Score comparison results

The mean final scores and the scores obtained in P1 and P2 (normalized over 10) by the past course students, the current course students that participated in the workshop and the ones that did not, are presented in Table 5.

After performing the ANOVAs, final scores of those students who participated in the workshop were obtained to be significantly higher (sig. ≤ 0.05) than the ones obtained by

students of the same course who did not participate in the workshop. Furthermore, they were also found to be significantly higher than the ones obtained the past course (sig. ≤ 0.05).

Table 5. Mean scores and SD obtained in the exams.

PART	PAST COURSE	PRESENT COURSE (WORKSHOP)	PRESENT COURSE (NO WORKSHOP)
P1	(M = 6.11, SD = 2.48)	(M = 6.33, SD = 2.44)	(M = 4.68, SD = 2.66)
P2	(M = 2.83, SD = 3.94)	(M = 4.08, SD = 4.16)	(M = 1.69, SD = 3.25)
FINAL SCORE	(M = 5.13, SD = 2.54)	(M = 5.88, SD = 2.59)	(M = 4.08, SD = 2.55)

5. Conclusions

In general, students gave high ratings when assessing the perceived benefits of having available the part proposed in the past course exam or the rubrics. They considered it helpful so as to improve their modelling skills, independently of their participation (or not) in the rubrics application workshop Moodle. These perceived benefit was even higher among subject's teachers.

Nevertheless, 58.8% of students that did not participate in the workshop alleged that they were not aware of the workshop methodology, so we will work to improve this aspect when tailoring future workshops. Furthermore, we will also have into account that those students who participated in the workshop considered more useful the self-assessment than assessing a classmate.

Regarding the score comparison, it can be observed that the scores of those students that participated in the workshop were significantly higher than those obtained by students that did not participate, and also higher than those obtained in the past course. It can also be observed that P2, corresponding to the more significant learning, is the part with higher score difference between those that participated in the workshop and those who did not (the score stills not being above 5, but it is pretty higher).These results evidence the benefit of the workshop in their skills, which was our main purpose.

The positive feedback received in the students questionnaires, the score comparison results and the high participation rate in the workshop and questionnaire (taking into account that both were not compulsory) encourages teachers to keep tailoring rubrics for the other parts assessed in the subject (technical drawings generation and assemblies), as well as proposing new rubric application by Moodle workshops.

Acknowledgements

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