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CONFERENCE PROCEEDINGS

**SEVILLE (SPAIN)
11-13 NOVEMBER 2019**



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CASE STUDY ON PEER ASSESSMENT PERFORMED BY ENGINEERING FIRST YEAR STUDENTS

J.M. Meseguer-Dueñas, S. Bernal-Perez, R. Sabater i Serra, R. Martínez-Sala, M.A. Gámiz-González, S. Quiles Casado, T. Garcia-Sanchez, J. Riera, J. Molina-Mateo, M.A. Serrano, J. Bonet-Jara, V. Donderis Quiles, A. Vidaurre, I. Tort-Ausina

Universitat Politècnica de València (SPAIN)

Abstract

This paper presents a qualitative study on the evaluation work performed by students of two courses, *Physics* and *Electricity*, included in the first year of *Electronic and Automatic Engineering Degree* (School of Design Engineering) at the *Universitat Politècnica de València*. The teaching methodologies used include continuous and formative assessment. The activity analyzed, based on peer assessment, consists of a problem to be solved by students. The solution is reflected in a document to be evaluated by other students and instructors.

In order to guide students in the evaluation process, a rubric was provided, which includes aspects to consider related to the assessment to be performed. In addition, effective communication transversal competence was assessed. Both tasks, problem resolution and evaluation, were performed in teams. Each team was made up of six members. The teams were the same in the two courses since they are consecutive, taught in first and second semester (one academic year). Each team had to solve six problems and evaluate six resolutions (from other teams) throughout both courses, without repeating the evaluated team (144 evaluations were analysed). The study has been developed in three parts; in the first one, it is analysed how the evaluation work of the teams evolved throughout the academic year. In the second part, the evaluations carried out by two different teams on the same problem resolution were compared, and finally, in the last part, the assessment made by students was compared with the one made by experienced instructors, both using the same rubric for the assessment.

The results of the study show that students carry out thoughtful and rigorous assessment work. It was also found that evaluations of the same work carried out by different teams resulted in very close ratings, which supported the credibility of the evaluations. Therefore, we can conclude that methodologies based on peer assessment encourage the active participation of students and enhance their learning.

1 INTRODUCTION

Peer assessment, as part of the constructivism framework, is a learning strategy in which students evaluate products elaborated by other students [1]. It promotes the developing of students evaluating skills, while engaging learners to build their own understanding. Peer assessment also improves the instructor assessment tactics. Technologic tools can facilitate the application of this didactic technique, promoting the interactions between students and providing a more motivating educational experience. Peer assessment has been described and analysed in different areas and its benefits have been extensively reported [2], [3].

The relative accuracy of peer ratings compared to instructor ratings is a major concern for both educators and researchers [4], [5]. Falchinov and Goldfinch [4], in a meta-analysis used estimated average Pearson correlation between peer and instruction ratings founded to be 0.69, moderately strong. The correlation was higher when a well understood global juice was used, instead of some individual dimensions. The results also showed higher significant correlation in advanced rather than beginner courses, and in science and engineering courses rather than other disciplines. Li et al. [5], in their meta-analysis from 69 studies on peer assessment since 1999 to 2016, obtained that the average Pearson correlation between peer and instructor rating was 0.63, similar to that obtained previously by Falchikov and Goldfinch. They studied different factors affecting peer assessment; among them, the correlation was significantly higher when assessments were performed by individual students rather than groups and non anonymous instead of anonymous. Furthermore, when peer

evaluators provided both scores and comments, the correlation was significantly higher than when only scores were provided. Harris [3], in a four years period study of peer assessment of laboratory reports, found an excellent correlation between peer and instructor marks. However, the grades achieved in academic work may vary, depending on the instructor. Even when grades awarded by various instructors agree, it does not necessarily mean a fair grade. Although many studies indicate that peer assessment provides adequate reliability and validity in some environments, the validity of peer assessment continues to be a topic for analysis and discussion [6].

In a previous work [7], the task object of students peer assessment was some resolved problems, written submitted and oral presented in groups. Students were provided by an evaluation rubric in advance. Both grades, students and two instructors were compared. The differences between students and instructors were of the same order as the differences between the marks of both instructors.

In this paper, peer assessment has been applied in first-year students during two different courses (in the same academic year). The aim of this study is to achieve a qualitative insight into three different aspects of the learning process: i) evolution of teams evaluation work throughout the academic year; ii) differences in the assessment carried out by two different teams on the same problem; and iii) comparison between the assessment performed by students and experienced instructors, both using the same rubric for this evaluation.

2 METHODOLOGY

2.1 Participants and context

This paper is based on a qualitative study on the evaluation work performed by students of first-year courses, *Physics* and *Electricity* (academic years 2017-2018 and 2018-2019) These two courses are included in the *Electronic and Automatic Engineering Degree* (School of Design Engineering) at the *Universitat Politècnica de València (UPV)*, and they are taught in the first and second semester.

The task object of peer assessment was a set of problems, solved by students in the same course.

Both the resolution of the problem and its peer assessment was performed working in groups. In each academic year teams of 6 students were formed. It turns out to be 12 or 13 groups, depending on the number of students. Those teams had the same components along two analysed courses. Thus, the continuity of the students' work is guaranteed. Assessments were organized preventing students from evaluate the same group more than once. Each team of students had to solve three problems and had to evaluate three resolutions each course. Finally, at the end of the two academic years 144 evaluations were performed.

The resolution of the problems had to be written following a specific report template, including the schemas, drawings and graphs required to solve the problem and make the resolution understandable. To do this, a support document was available for the students. In this document, a guide for written the report was included, as well as a rubric, which had to be use for report preparation and assessment. Table 1 shows the different categories in the rubric and its weight in the assessment (the full rubric is included in the Annex).

Table 1. Categories of the rubric and its weight in the evaluation

Category	Weight (%)
Components of the problem and organization	15
Structure: Grammar of written text, schemas, drawings and graphs	35
Resolution: explanation, calculation, results and discussion	40
Knowledge of the subject	10

Figure 1 shows the organization of the work. An assignment was created in the university online teaching platform (*PoliformaT*, based on Sakai technology). In this assignment, the problem that each team had to solve was specified, as well as the corresponding evaluator team. In addition, the deadlines for submission of both the problem resolution and the evaluation were announced. The

reports have to be uploaded by students in a specific folder created at the online platform, where all of them can create, read, edit and delete their own resources.

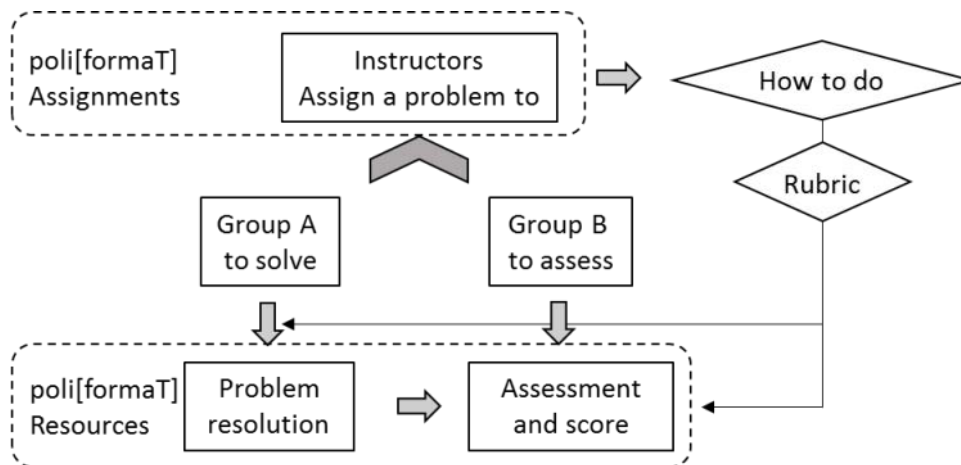


Figure 1. Diagram of how the team work is organised: problems resolution and peer assessment.

2.2 Analysis of the assessments

The study has been developed in three parts. In the first part, it was analysed how the evaluation work of the teams evolved throughout the academic year. To do that, a detailed follow-up was carried out on the assessments performed by three teams throughout an academic year (3 problems of *Physics* and 3 problems of *Electricity* for each team), which lead to 18 assessments to be studied. In this analysis, the focus was on the evolution from the perspective of the appropriate use of the rubric and the accuracy in the correction.

During the academic year 2018-2019, four problems of the *Electricity* course were evaluated by two teams simultaneously. This allowed us to compare the assessment of the same problem performed by two different teams (second part of this study). The analysis focused on the partial grades given to each category of the rubric, the final grade and the comments made by the evaluation team.

Finally, the final grades awarded by the students have been compared to the one awarded by the instructors. To do so, one problem of each assignment of each course has been randomly selected (12 problems out of the 144 included in this paper). These 12 problems were assessed independently by three external instructors following the same rubric as the students. The three instructors belong to the Physics Applied Department, but only one of them was conducting the courses and, therefore, this professor was the one with a better knowledge of the objective and methodology of the courses.

3 RESULTS

The number of documents analysed rises to 144 evaluations, corresponding to two consecutive courses in the same academic year (academic years 2017-2018 and 2018-2019). The students following the courses were divided in 12 teams, and each one of them had to solve six problems and evaluate six resolutions (from other teams) throughout both courses, avoiding evaluating the same group twice.

Overall, the evaluation reports presented by the students have a good quality level, following the standards of academic and scientific reports, which is important taking into account that they are first-year engineering students. All their critical comments have been rigorous.

The assessment of the problem resolution was done correctly in almost all cases. Only rare exceptions were found with wrong resolutions considered as right ones.

Three different analysis have been performed:

- A follow-up of the evolution of the six different assessments made by each group, from the first one, at the beginning of the first semester, to the last one, at the end of the second semester.

- An analysis of the differences in the assessment of the same problem carried out by two different teams.
- A comparison on the assessment made by students with the one made by instructors, both using the same rubric.

The results of these analyses are shown in the following subsections, with a partial discussion and final conclusions.

3.1 Evolution through the academic year of the different assessments performed by each group

In this case, evolution of three teams is analysed throughout their six documents in a year. It means a total of 18 documents.

The following results were observed:

- All the teams used the rubric for their assessments.
- The students understand how they should evaluate using the rubric, and it is maintained throughout the academic year.
- All the teams added comments to their assessment, pointing out the mistakes and the right way to solve the problem.
- In the most difficult problems, the comments are very detailed.
- The students demonstrate a good knowledge of the matter they are evaluating.
- There is not enough information to confirm if all the components of the team have participated in the assessment of one specific problem.
- The comments (level of detail) of a team is not homogeneous comparing different problem assessments, which could indicate that not all students in a group are involved in all the assessments.
- As the level of difficulty of the problems is different depending on the topic under study, it is challenging to follow accurately the evolution of the assessments performed by each team.

3.2 Differences on the assessments of the same problem performed by two teams

The previous qualitative analysis indicates that students understand how to evaluate using the rubric, leading us to think that similar results are expected from the assessment performed by different groups. In order to address this point, the assessment of four problems (*Electricity* course) by two different groups has been analysed. The justification of the scores in each category of the rubric and the final grade awarded by each team has been included.

The students follow the rubric provided to guide them in the assessment of their peers. In this way, if the evaluation were performed correctly, similar results would be obtained. A maximum discrepancy in the different categories of the rubric of one level (1 point) between both evaluations is allowed.

Four exercises were solved in the subject *Electricity* (second semester) by two different teams. Written comments, each category rating and the final score awarded by both teams were analysed.

In the assessment reports studied, the coincidence in the evaluation of the different categories is within acceptable values in the initial hypothesis (one level of discrepancy). In three of the cases, the result of the final score has been of the order of one tenth (0.1), and only in one case has it been higher (0.8 points), confirming that the differences in the rating of the categories are compensated, giving an equivalent final score.

The comments and observations made by the assessment teams were appropriate, considering the formal aspect of the assessment report and the important level of detail, with a good level of agreement between both groups. This fact highlights that a rigorous evaluation work has been attempted. The coincidence in the judgements made by the two corrector groups is quite high, and only in one case the comments are very short since they consider them unnecessary because of the high quality of the work. Therefore, the formative evaluation nature of this methodology must be

considered. It allows the student to reflect on the work done by their peers, and as a result, learn about the content of the work evaluated, and acquire their own evaluation skills.

3.3 Comparison of the assessment performed by students and instructors.

For this analysis, one problem from the six assignments of each course has been randomly selected (12 assessments out of 144). Three instructors have independently assessed them using the same rubric and the results of the evaluation have been compared with the assessments performed by the students. One of the instructors is conducting the course (Professor 1) and knows the objectives and methodology used, while the other two are teaching in other grades (External professors).

The overall results of the assessment score are shown in Figure 2 (2a, 2b and 2c), which compares the qualifications of the instructors (Professor 1, External professors average, and the mean of all of them) vs students.

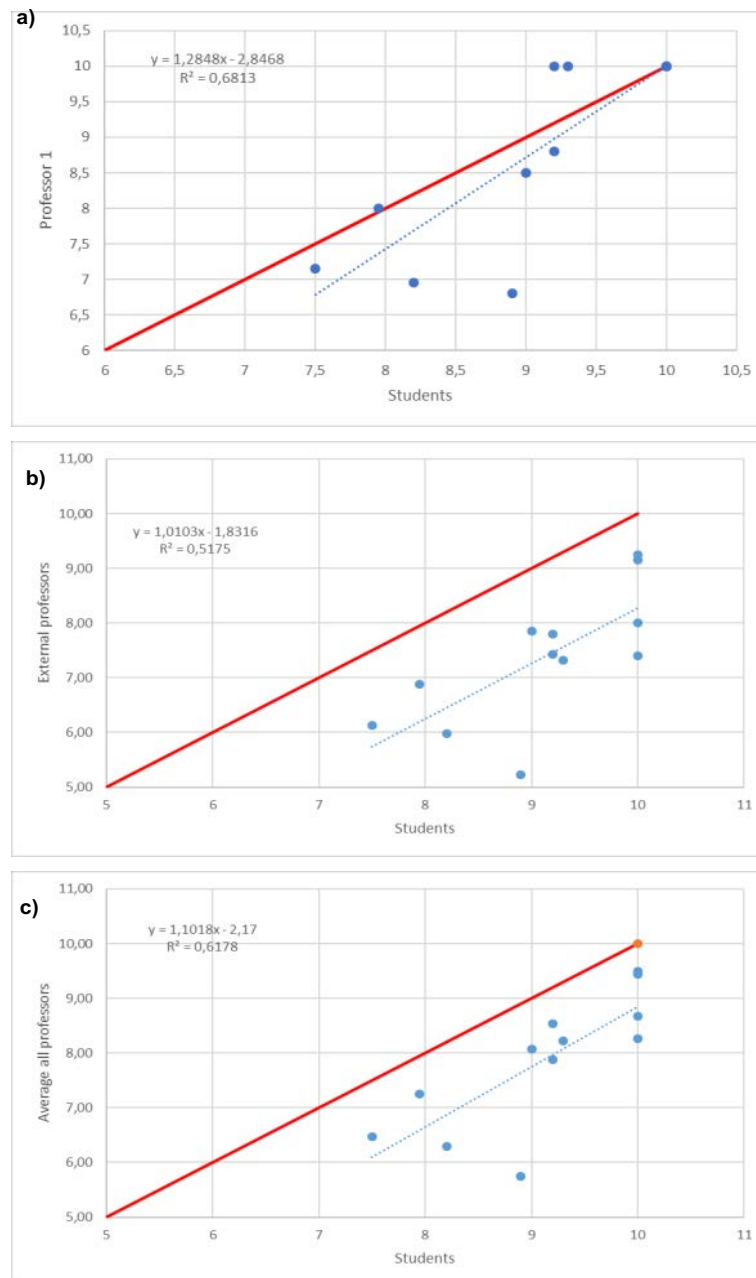


Figure 2. Scores awarded by a) Professor 1, b) External professors and c) average professors vs. students. In each graph, the angle bisector is shown in red and data are fitted to linear regression (dotted line), which equation is also included.

It is worth noting that most of the points are below the bisector, indicating that the scored awarded by the instructors is lower than that of the students.

The same comparison has been made using Bland-Altman plots (Figure 3). The horizontal axis represents the average of the two grades to be compared (Student and Professor) and the vertical axis represents the difference (Student-Professor). The zero-line, which would indicate that the difference is null, is plotted in red. The mean difference is represented in orange to see if there are significant differences. The position of the standard deviation from the mean is represented in green, both the positive and negative values.

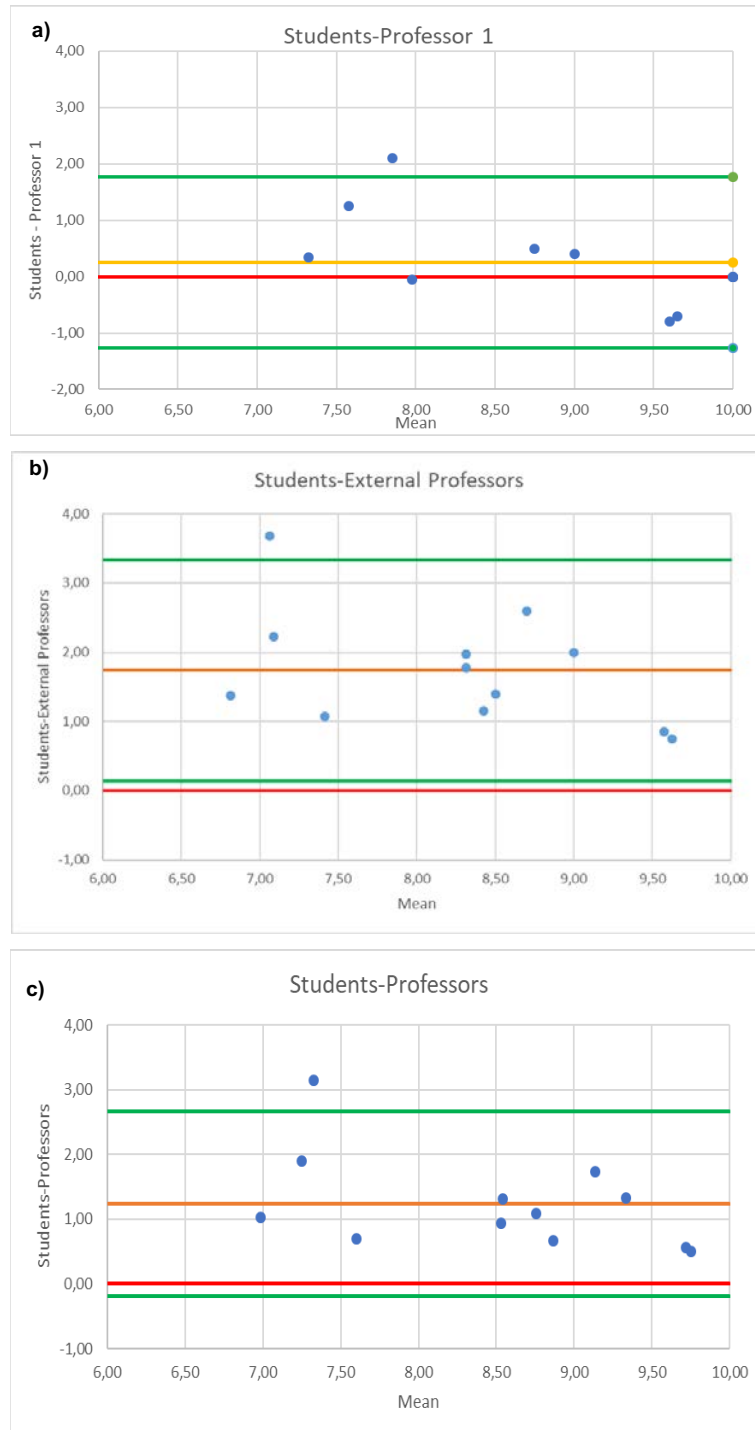


Figure 3. Bland-Altman plots. The horizontal axis represents the average of the two grades to be compared (Student and Professor) and vertical axis represents the difference (Student-Professor), corresponding to a) Professor 1, b) External professors and c) Professors' average.

The mean of the differences and their standard deviation are summarized in Table 2.

Table 2. Mean of the differences between students and professors' grades and standard deviation.

	<i>Professor 1</i>	<i>External professor 1</i>	<i>External professor 2</i>	<i>Average external professors</i>	<i>Average Professors</i>
<i>Average of differences</i>	0,25	2,32	1,15	1.74	1,24
<i>Standard deviation</i>	0,756	1,192	0,861	0,799	0,714

Data analysis indicates that instructors correct significantly different from each other and different from the students, even using the same rubric. Professor 1, who knows the methodology and objectives of both subjects, offers a result more similar to the students' one. Although the results are not statistically significant (only three instructors and 12 problems), the results seem to point out that the rubric is not good enough to unify criteria and even a deeper issue, implicit in the evaluation, which is the direct knowledge of the subject.

There is no temporal correlation when analysing the differences in the assessments of students and professors as a function of time, in order to study whether as the course progresses the differences decrease due to the unification of criteria. Differences between student and teacher assessments are randomly distributed throughout the course.

Statistically significant differences between instructors and students have been found, and even between different instructors. The difference between the instructor who is familiar with the courses and their teaching methodology, and the external instructors who are not familiar with the courses may be relevant. This difference could be an objective of a further research. The results obtained suggest the existence of tacit correction criteria in the subject context, which are not reflected in the rubric, which is focused only in the direct knowledge of the subject under assessment.

4 CONCLUSIONS

Peer assessment carried out during two courses, *Physics and Electricity*, included in the first year of *Electronic and Automatic Engineering Degree (Universitat Politècnica de València)*, has yielded interesting and stimulating results:

- The peer assessment methodology manages to involve students in this formative evaluation model.
- The evaluations, in general, have a critical and rigorous approach, both in relation to the resolution of the problem and in the formal aspects of the document evaluated.
- The rubric proposed for the evaluation has been accepted and used by the students without any problem and correctly.
- When analysing the evaluations performed by two teams on the same document, they coincide in a reasonable way in the assessment of different aspects of the rubric and in their comments, and the final rating deviates little. This indicates that students know the objectives of the work and the evaluation criteria, and apply them similarly in the evaluation. Furthermore, a deep reflection on the work carried out by the peers has been achieved by the students through this methodology. Peer assessment helps students to learn about the work performed by other students as well as to have a better understanding of the subject.

However, after the analysis of the results, weak points have been identified for further improvement:

- There has been no clear evolution in the evaluation carried out by teams throughout the course; from the beginning to the end it seems that they follow the same guidelines.
- Comparing the assessment carried out by the students with that carried out by the instructors, the results are not conclusive and the evaluation should be extended to other instructors in order to be able to get accurate statistics of the results. In particular, the concrete aspects that should be addressed are:
 - There is a bias towards a higher score of student assessments with respect to that of the instructors.

- The bias is lower when comparing the student assessment with the instructor who teaches the course. This seems to indicate, although there is only a few data, that if the students and instructors share the same learning context, they coincide in the evaluation and apply similar subjective criteria.
- There are differences in the evaluation between instructors outside the course context and instructors conducting the course.
- The difference between the assessment performed by different instructors seem relevant, depending on whether they are involved in the context of the course (not only the contents and objectives), and should be investigated more specifically.

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ANNEX (EVALUATION RUBRIC)

Problems resolution /Evaluation Rubric

CATEGORY / LEVELS	4 (10 points)	3 (8 points)	2 (5 points)	1 (2 points)	100%	0
A) Components of the problem and organization	All required elements are present. The contents are well organized and present a professional appearance.	All required elements are present. The contents are well organized.	Few required elements are missing. The format of the report does not help to organize the material and to understand the contents. It has incorrect format.	Several required elements are missing. The document is sloppy, misspelled, font types and sizes are not homogeneous, graphs and tables badly inserted, ...	15%	Does not contain the minimum requirements to be considered as a problem resolution.
B) The form: grammar, sketches, drawings and graphics	The text is excellently written. The vocabulary and language are academic and are related to the content. Professional and accurate sketches, drawings and graphic representation. The graphs are labelled and titled.	The text is written correctly. The vocabulary and language are correct. Accurate representation of sketches, drawings and graphs. The graphs are labelled and titled.	The text, drawings and graphics are understood, but carelessly presented and unclear.	The text presents grammatical errors and inappropriate vocabulary. Several sketches, drawings and graphics necessary for the resolution and interpretation of the problem does not appear.	35%	
C) Resolution: development, calculations, results and discussion	The development is logical and organized. Mathematical explanation of each of the steps in the exercise is performed correctly. All calculations are shown, the results are correct and properly expressed with their units. Nomenclature is used properly. Results are discussed. If applicable, it includes the findings and what was learned from the problem from a critical point of view	The development is logical. Mathematical explanation of each of the steps in the exercise is showed. Some calculations are shown, the results are correct and properly expressed with their units. Results are discussed, but not clearly. If applicable, it includes the findings and what was learned from the problem.	Mathematical explanation of each of the steps in the exercise is showed. Some calculations are shown, the results are properly expressed with their units. If applicable, it includes what was learned from the problem.	No calculation is showed.	40%	
D) Knowledge of the subject	The theoretical concepts are fully applied, showing full understanding of physical concepts.	Theoretical concepts are properly applied, demonstrating adequate knowledge of physical concepts.	The application of some of the theoretical concepts is incorrect. Some concepts are not properly assimilated.	The shown knowledge is deficient.	10%	