THE USE OF RUBRICS FOR THE EVALUATION OF THE SUBJECTS' PRACTICES IN ENGINEERING STUDIES, CONSISTING IN SOLVING REAL CASES IN DIRECT CONTACT WITH COMPANIES: THE CASE OF THE PROJECT EVALUA-PRACTIC

B. Urbano[1], X. Gómez[2], M.E. Sánchez-Morán[2], R. Mulas[2], M.I. San-Martín[2], R. Mateos[2], C. Fernández[2], O. Martínez[2], A. Moran[2], F. González-Andrés[2]

[1]Teaching Innovation Group INGENIAQ. Universidad de Valladolid (SPAIN)
[2]Teaching Innovation Group INGENIAQ. Universidad de León (SPAIN)

Abstract

Background: The teaching methodologies need to be renovated in order to promote the active students' contact with the labour market, especially in the engineering studies. The direct contact between the students and the companies is a key point in the capacitation of engineers, because they need to be not only creative and innovative, but also realistic. The Teaching Innovation Group (TIG) INGENIAQ (University of León, Spain) has started in 2016 an experimental action to put in contact the engineering students and the companies by means of the subjects' practices. The subjects' practices consisted on real problems from real companies, which should be solved by the students using a methodology based in two main pillars: i) a direct interaction student-company, and ii) the use of a "flipped classroom" methodology. This has been applied to several subjects, belonging to the following studies: agricultural, environmental, chemical and industrial engineering, at the level of "Degree" and "Master". However, we have faced the problem that this kind of practices which are not the typical ones, are difficult to evaluate. To solve this situation, the TIG INGENIAQ has started the project EVALUA-PRACTIC with the purpose of developing a collaborative evaluation of the subjects' practices described above.

Objectives: The general objective of the project EVALUA-PRACTIC was to develop, to test and to evaluate, a methodology based in rubrics, for the evaluation of the subjects' practices, involving all the actors in the teaching-learning process: The teachers, the representatives from the company, and the students. This work presents the first results of the project. The specific object of this work was to develop a scoring system for the subjects´ practices which is clear, objective and repetitive, based in rubrics.

Methodology used in this work: In the first stage, the teachers created a rubric for each subject following the next steps: i) to split the work into its component parts, considering the competences to be achieved with the practices; and ii) to stablish a rating scale for each part, providing a detailed description of the yield levels required for acceptance. In the second stage the representatives of the company collaborated in the optimization of the rubric design, taking into account what companies are looking for in the new professionals.

Results and prospective actions: The work analyses the common and the specific characteristics of the developed rubrics, for the different engineering subjects included in the action. During the second semester of the course 2017-2018, the rubrics will be applied in two different ways: The teachers will evaluate the practical activities of the students, and the students will auto-evaluate their progress. Finally the results obtained by the teachers after the application of the rubric, and those of the auto-evaluation will be compared in order to identify the points of discrepancy, which will indicate the weakness of the system because a lack of alignment between the students perception of the activity and the teacher expectations with it.

Keywords: Rubric, flipped classroom, engineering, entrepreneur.

1 INTRODUCTION

The guidelines for the modernization of the higher education according to the objectives of the Europe Strategy 2020, have been delineated by the European Commission in 2014, with the Agenda for the Higher Education Modernization [1]. The Agenda established the priority to adjust the higher education

ISBN: 978-84-697-9480-7

studies to the labour market, promoting the entrepreneurial spirit and enhancing the links between education, research and enterprise.

Additionally, the teaching and learning process proposed by the Bologna process, encourages an active participation of the students in the learning process. More relevant become these statements for engineering studies due to the need of its pragmatic approach. In these studies, the enterprise, the research and the universities must be collaborating closely.

Moreover, the Spanish National Agency for the Higher Education Quality [2] advices to reinforce the actions to close the studies to the professional sectors in order to support continuously the students in the access to the labour market.

As a consequence of the European and National mandates, during the last few years several attempts have tried to integrate the students in the professional sector throughout the whole curriculum of the University studies, and not only in the “curricular practical credits” [3]. As an example, the Teaching Innovation Group (TIG) INGENIAQ (University of León, Spain) has re-designed the **subjects’ practices** of the engineering studies, in such a way that the students have to solve a real case or problem from a real company [4]. The methodology includes the following key points: i) Direct interaction between the students and the company; ii) the use of the Flipped Classroom Methodology [5], in which the students gain first exposure to the topic by the practices, and afterwards the time in the classroom is used to do the harder work of assimilating the knowledge; iii) the use of Information and Communication Technologies (ICT) [4].

Such uncommon practical activities pose the threat of how to evaluate them, because the traditional systems are not adequate. It is therefore necessary to develop a new evaluation system, which must be continuous, formative, shared and based in competences in order to align the evaluation and the learning outcomes [6]. After the Bologna process it is necessary that the students participate in all the evaluation processes, especially in the practical activities, because they are key pillars to support the whole teaching-learning process. Consequently, the students must auto-evaluate the quality of their work and they must to understand how to improve it. In such a way, the students will gain responsibility in their own learning process. The criteria for the evaluation are included in the so called rubrics, which are instruments for the continuous evaluation oriented to the learning [7].

The concept of rubric is unfocused according to the literature [8]. We have adopted the concept of Stevens and Levy [9]: “tool for the evaluation of the students which split the work in its component parts taking into account their objectives, and which provides a detailed description of the levels of acceptance or not for each of the component parts”.

The **general objective** of the present work was to develop and analyse the rubrics’ design for the evaluation of the subjects’ practices in engineering studies. The peculiarity of the subjects’ practices is that the students have to solve a real problem of a real company, ideally having a direct contact between the company representatives and the students. The rubric design process will involve the following actors of the teaching-learning process: The teachers and the representatives from the company. The **specific objectives** of this work were to develop the rubrics for the evaluation of the practical activity of five subjects from Engineering studies, to find the weak points and the inconsistences of the rubrics design process, and to stablish the best procedure to design successful rubrics. The prospective phase of the work will be the pilot application of the rubrics to the evaluation of the subjects.

2 METHODOLOGY

2.1 Subjects included in the pilot experience

The subjects included in the pilot experience of design rubrics, for the shared evaluation of the practical credits, are presented in Table 1.

Table 1. *Subjects included in the pilot experience of design rubrics for the shared evaluation of the practical credits.*

Subject	Level	Knowledge area	Studies
Ornamental crops	Grade	Production	Agricultural Engineering
Biotechnological processes	Grade	Engineering	Biotechnology
Plant Production Systems	Master	Production	Agricultural Engineering
Business administration and Marketing	Master	Economy	Agricultural Engineering
Innovation in industry	Master	Engineering	Production in Pharmaceutical Industry

2.2 Rubric development

The sequential steps for the development of the rubrics have been adapted from Romeo et al. [10]:

Preliminary phase

Kick-off meeting of the TIG members to clarify the objectives of the pilot phase. The convenience of the use of the freeware software RUBISTAR was also discussed in such first meeting.

Phase 1. Definition of the dimensions to be evaluated and the indicators to evaluate them

Action 1.1. Definition of the dimensions

The dimensions are the logical and natural components in which a competence can be split, in order to analyze, teach, learn and evaluate it.

The dimensions were defined by the teachers.

Action 1.2. Definition of indicators

The indicators are proofs or evidences, and as a consequence the indicators must be expressed as descriptors hierarchically arranged. Each teacher designed the indicators for each dimension, taking into account the main elements of the learning guide as the competences and the learning outcomes.

Phase 2. Elaboration of the rubric

Action 2.1. Quality definitions

In general terms it is recommended [7], [10], to define three levels about the quality of the solutions reached by the students, the first one related to the novel expertise, the second one with the advanced expertise, and the third one with the expert one.

Each teacher selected the quality levels for each indicator. In this phase some of the teachers decided to use the RUBISTAR software.

2.3 Rubric analysis

Phase 3. Validation of the rubric involving the teachers in the TIG and the company representative

Action 3.1. Cross-validation of the rubric inside the TIG

It has consisted on a group discussion among the members of the TIG, in order to find weak points, inconsistences, or critical points. Therefore it reflects the opinion of the academic world.

Action 3.2. Validation with the company representative

After the validation of the rubric inside the TIG, the final proposal was shared with the company representative. As a consequence, we obtained the following information:

1 suitability of the competences covered by the subjects' practices to the company requirements from the future professionals

   This information will help to the future revision of the "teaching guide", although it is not directly related with the purpose of the present activity.

2 suitability of the dimensions selected, the indicators and the quality definitions.

This information from the company will help the teachers to understand if there is the adequate alignment between what the academic world considers important for the graduate and what the business world expects from the future professionals.

The information obtained from the action 2.3 helps to understand the weak points, inconsistences, or critical points, in the opinion of the business world.

2.4 Following steps

The following steps, out of the scope of this publication, will be the use of the rubric for the evaluation of the practical activity of the students. The practical activity will be introduced to the students. It wiill consist in the solution of a real case or problem in a real company. The teaching methodology will be flipped learning, which means that the practical work will precede the explanation of the theoretical concepts. From the first moment, the students will be informed about the content of the rubric, and the evaluation process, because the evaluation system will be shared-evaluation.

The rubrics will be used by the teacher to evaluate the students and by the students for self-evaluation.

3 RESULTS

A summary of the characteristic of the subjects included in the pilot phase for the development of rubrics is given in Table 2. The information included is a brief description of the practical activity and a summary of the competences evaluated.

Table 2. *Brief description of the practical activity corresponding to each subject, and the competences evaluated with such practical activity.*

Subject (knowledge area)	Level	Activity	Competences to evaluate
Ornamental crops (Production)	Grade	Consultancy activity to solve a technical problem of a company	Ability to compile and understanding relevant data to be able of interpreting complex reasoning; to communicate own ideas in technical but not expert auditorium
Biotechnological processes (Engineering)	Grade	Formulation of a research project for a company	To make decisions and to solve problems; creative and innovation ability
Plant Production Systems (Production)	Master	Consultancy activity to solve an agronomic problem of a company	To develop autonomous learning abilities; to integrate different knowledge packages in order to be able to face complex decisions; to communicate own ideas in technical but no expert auditorium
Business administration and Marketing (Economy)	Master	Development of a marketing plan for an agro food industry	To summarize and synthesize; to communicate own ideas in technical but not expert auditorium; critical thinking
Innovation in industry (Engineering)	Master	Formulation of an innovation project	Ability to plan and execute R&D activities at technical-scientific level and compliance of the technical-economic requirements to formulate projects; to make decisions and to solve problems; creative and innovation ability

Table 3. Relative importance (in percentage) of the dimensions and indicators considered in the rubrics developed for the five subjects analysed in this work.

Dimensions	Indicators	Ornamental crops	Biotechnological processes	Plant Production Systems	Business administration and Marketing	Innovation in industry
Understanding of the problem and search for information about the state of art	Ability to understand the problem to be solved	15 %		15 %		
	Ability of searching information to make an adequate state of art	15 %		15 %		
	Level of interaction with the company	15 %		15 %		
Written document to be presented to the potential client	Excellence in innovation proposals	15 %	17 %	15 %		30 %
	Technical and methodological excellence	10 %	17 %	10 %	37,5 %	
	Technical viability of the proposal	15 %	17 %	15 %	25,0 %	30 %
	Socioeconomic impact		17 %			
Oral presentation to the potential client, academics and company representative	Quality of the presentation from the formal viewpoint	10 %	33 %	10 %	25,0 %	15 %
	Quality of the responses to questions from the company supervisor and from the audience	5 %		5 %		15%
In classroom activities	Attendance to the classes and attitude during the presentation of problems from other students				12,5 %	10%

There was a great variability in the relative importance of the dimensions and indicators for the different subjects, as can be seen in Table 3. Moreover, the same competence was evaluated with different dimensions and indicators in different subjects, because the selection of the dimensions and the indicators depended on the teacher's criteria. However, in subjects of the same knowledge area, the dimensions and indicators used to evaluate the same competences, were more similar, because the subjects of a given knowledge area were covered either by the same teacher or by teachers of the same work team. For example, the dimension "Understanding of the problem to be solved, and search for information about the state of art" was only considered in two subjects of the knowledge area of Plant Production, whereas the indicator "socioeconomic impact" was only considered in the subjects of the knowledge area of Engineering Processes. On the other hand, the subject Business Administration and Marketing was the only one that did not consider indicator about innovation, specifically "Excellence in innovation proposals". Finally, the dimensions and indicators related to the interaction of the students with the audience, during the presentation of the works, did not show any kind of relationship with any knowledge area.

3.1 Weak points of the rubrics design process

The detection of the weak points or inconsistences of the rubrics was carried out in a two-step process, which involved a cross-validation of the rubric inside the TIG, plus a validation with the company representative.

Figure 1 shows the steps in the design and application of the rubric, in dark blue those analyzed in this work, and in light blue the rest. The main weak points detected by the cross-validation process are showed by a red asterisk, whereas those detected by the business sector are showed by a green asterisk.

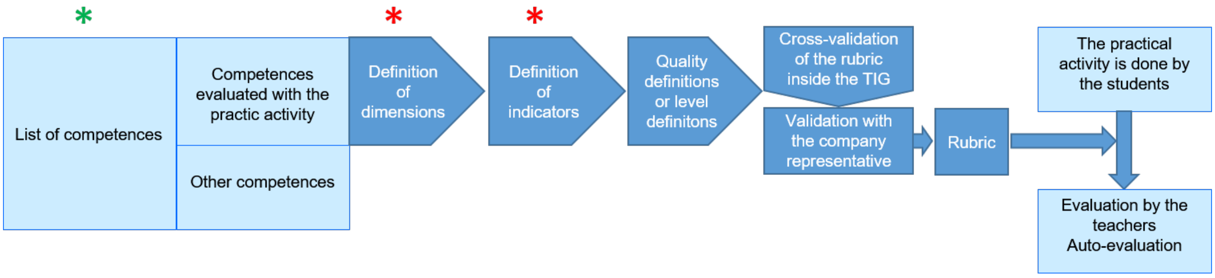

Figure 1. Steps involved in the design and application of rubrics for the evaluation of the practical competences of engineering subjects. In dark blue the steps included in this work and in light blue the rest of the steps. Red asterisks indicate the weak points detected in the cross-validation inside the TIG, and green one those detected by the business sector.

The cross-validation of the rubric inside the TIG, revealed that the two main weak points are related with the definition of the dimensions, and the definition of the indicators. Such weak points consist on the great variation of approaches for the same competences in different subjects, depending on the teacher. This situation can confuse the students. Therefore, it should be necessary a coordination effort in the formulation of the rubrics, because the same competences should be evaluated at least with the same dimensions, and the differences in the indicators should be kept to a minimum. The main differences between the rubrics of the different subjects, should be about the definition of the quality levels. The standardization of the basic, general and transverse competences, has given good results at the University system, and now it is a common practice, supported by some software programs. Consequently, it could be necessary to standardize also the dimensions and indicators of the rubrics. An attempt to achieve this standardization is the freeware RUBISTAR, but it lacks specific information for Engineering studies.

The validation with the company representatives revealed that the main lack of alignment University-Business sector could be more related with the execution of the competences. According to the companies, the students show difficulties to make their own decisions and to assume responsibilities, because they rely excessively in the group decisions, supposedly as a consequence of an inadequate interpretation of the "group work" in the university studies. Even if the autonomous work is included among the competences, the graduates clearly do not acquire this competence.

3.2 Implication of the work and prospective evolution

In our case, as already indicated by Romeo et al. [10] in their work, the design of the rubrics has been useful to draw a clear schedule of the organization and suitability of the of the teaching processes and methodologies. In this sense the rubrics can be an important instrument for the formative assessment of the students. The rubrics must be shared between the teachers, the representatives from the company, and the students. In the design phase, the participating actors have been the teachers and the representatives from the company, but in this phase the students are not included, as already suggested by Stevens and Levy [9]. The students will be included in the next phase in order to self-evaluate their work using the rubric, and this will permit to compare the teachers' criteria and the students' expectatives. The students will know the rubric before starting the activity, and therefore they will understand more clearly from the beginning, the criteria for the evaluation of the activity.

This work has analysed the critical points in the design of a rubric, whereas the prospective steps will be the following:

- Application of the rubrics for the evaluation of the students' practices: In the one hand the rubric will be used by the teachers to evaluate the students, and in the other hand the students will self-evaluate their own practice work using the rubric.
- Analysis of the discrepancy between the teachers' and the students' opinion, which will led to detect the points of lack of alignment between the teachers' criteria and the students' expectatives.

- Analysis of the reproducibility of the evaluation results using the rubric, for different teachers in the same subject and the same group of students.

4 CONCLUSIONS

The main conclusions are the following:

With this work we have developed the rubrics for the evaluation of the practical activities of five Engineering subjects, and we have evaluated them in a two-step process including a cross validation inside the TIG, and a validation with the company representative.

As a consequence of the cross-evaluation process, we have detected that a weak point of the rubrics is that there is a great variation of approaches for the same competences in different subjects, depending on the teacher. To solve this situation which can confuse the students it should be necessary a coordination effort in the formulation of the rubrics.

The companies' representative highlighted that the main weak point of the teaching-learning system at the University studies, is the lack of achievement of the competences related with the autonomous and individual work, and that the graduates have fear to make decisions.

ACKNOWLEDGEMENTS

The work has been financially supported by the "*Escuela de Formación*" from the Universiy of León, by means of a project from the call "PAGID-2017" named EVALUA-PRACTIC.

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