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ELABORATION OF RUBRICS FOR THE EVALUATION BY COMPETENCES OF PHYSICS IN THE UNIVERSITY

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Abstract

The competency-based educational model, that initiated at the beginning of the XXI century plays a very important role during the teaching-learning process in higher education institutions, it establishes that for the development of the human being education must be integral.

Competency-based education is oriented towards an evaluation model linked to student training, in order to foster the development of skills and abilities to identify, project, solve problems and make decisions. In addition, it promotes the pursuit of meaningful learning and fosters collaborative work.

In this context, the rubrics of competency evaluation appeared as a tool that allows obtaining evidence of the acquisition of competences and application of knowledge outside the classroom. This implies a change in the university's scenario, both for teachers and for students, as there are new roles and tasks to achieve learning based on generic and specific competencies.

In this work, we present a proposal of rubrics for the evaluation by Physics Competences in the university field, specifically, to evaluate the development of laboratory practices. Also, we want to introduce new assessment methods and identify opportunities to develop skills and evaluate learning through indicators of progress.

In this first phase, we have designed a laboratory practice, and we have developed the evaluation rubric applied to students of Physical Foundations of Informatics in the Degree of Computer Engineering of the Higher Polytechnic School of the University of Castilla -La Mancha (UCLM), located on the university campus of Albacete.

Keywords: Competency-based approach, rubric, teaching-learning, and competency assessment.

1 INTRODUCTION

In recent years, the different educational levels continue adopting the competency-based education model as a quality assessment system [1]. The professionals create improvements and innovate techniques and tools that contribute to the implementation of this model and that allow to demonstrate their results. In Mexico, in the late 1980s the National Vocational Training College (CONALEP) adopted some proposals from Australian Andrew Gonczi for the training in competencies in the technical education [2] and, at the same time in Mexico this approach was being introduced [3], whereas in Europe the discussion of this subject in the technical training was starting [4].

In this context, the competency evaluation becomes one of the most important tasks of the educational processes because of its formative usefulness in the learning of the students [5-7]; since it integrates knowledge, abilities, skills, attitudes, values and norms that allow to provide the student with an integral formation to confront and give solution to the problems in the work field [8].

To achieve a competence, it is necessary to master specific information, at the same time, develop a series of skills derived from the information process, but in a problematic situation, that is, in a real unpublished circumstance, where the competence can generate and acquire [4].

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To demonstrate that the student is competent, it is necessary the evaluation that evidences the learning, for this, it is required the use of instruments that are appropriate to the competencies that will be evaluated during the training process; and by this form, through these instruments make judgments of value as accurate, precise, fair and transparent as possible [9]. In order to carry out this evaluation, the so-called rubrics can be used, since they clearly define all the criteria to be evaluated and the percentages that the student will receive, also, is specifies the deliverables and the competencies to be demonstrated by the Student.

The first rubric dates back to 1912, derived from a study carried out by Noyes, who needed to develop an objective instrument to evaluate written texts including indicators with the same meaning for all people and places. This is how the rubric called Scale for the Measurement of Quality in English composition by Young People emerges [8].

The rubric is an instrument that shares with teachers and students the necessary criteria to carry out learning and evaluation tasks. It is like a task guide that shows the expectations that students and faculty have and share about an activity or several activities, organized in different levels of compliance: from the least acceptable to the exemplary resolution, from what is considered insufficient to excellent [10].

According to what you want to evaluate changes the purpose of the rubric, therefore, are classified in two types, holistic/global or analytical [4,11], and their difference is that the first one does not separate the parts of the activity to be evaluated, that is to say, a global description is made without specifying the components of the process; whereas the second, clearly details the indicators of each activity and specify the evaluation criteria according to the level of performance of the student [10]. Nowadays, the rubrics have become a valuable tool for the evaluation of the competencies approach.

This paper presents a proposal for an analytical type rubric for the evaluation of Physics competencies at a university level, specifically, to evaluate the development of laboratory practices. Thus, with the purpose to introduce new evaluation methods and identify opportunities to develop skills and evaluate learning through progress indicators.

En esta primera fase hemos diseñado la rúbrica de una práctica de laboratorio, y hemos desarrollado la rúbrica de evaluación aplicada a estudiantes de Fundamentos Físicos de la Informática en el Grado de Ingeniería Informática de la Escuela Superior Politécnica de la Universidad de Castilla-La Mancha (UCLM), ubicada en el campus universitario de Albacete; misma que será implementada y posteriormente se evaluará su impacto.

In this first phase we have designed the rubric of a laboratory practice, and we have developed the evaluation rubric aimed to students of Physics fundamentals of the informatics in the computer engineering degree of the Polytechnic School of the University of Castilla-La Mancha (UCLM), located in the university campus of Albacete; the same that will be implemented and then its impact will be assessed.

2 METHODOLOGY

The laboratory practice "*Measurement of the magnetic field of a small magnet*" [12] is being used since 2015 with students of the subject Physics foundations of informatics that students study in the computer engineering degree of the Superior School of Computer Engineering of the University of Castilla-La Mancha (UCLM), located in the university campus of Albacete, Spain.

The competency-based educational model continues to be present at different levels of education, as a system that contributes to improving the quality of education and training competent students to solve problems. Consequently, it has created in the professors the need to search and design objective evaluation instruments such as the rubrics, and the University of Castilla-La Mancha is already working with this model and is responsible for the teacher training by providing guidance on how it should be implemented and, in this case, as on how the competency assessment should be through the use of rubrics.

When we have the rubric validation, two study groups and two teachers from the physics area (one teacher for each group) will be selected in order to work with these two groups (A and B) as follows:

- Group A will develop the practice in the Physics laboratory but without providing the rubric evaluation by competences and after being developed, the assigned professor shall be asked to correct the results of that practice in order to evaluate it without the help of the rubric; once this process has been completed, an assessment will be made of the degree of difficulty and the levels of the students' perception as solvers of the practice and an evaluation to the teacher as the one responsible to correct and assign a grade to the students.
- With group B, this same activity will be carried out following the process described above, but this time providing the students and the teacher with the practice together with its evaluation rubric; in order for the student to resolve it and the teacher to correct it and to assign a grade to the students

Once these two evaluation processes have been completed, the degree of difficulty, levels of perception and usefulness of the application of rubrics both with students and teachers will be assessed. Subsequently, an analysis of the results of both evaluations will be carried out, as well as the grades obtained by the students of each group (A and B), and finally a comparative analysis of both study groups, in order to identify the impact that generates the use of rubrics as competencies evaluation instruments.

3 RESULTS

The following is the evaluation rubric linked to a laboratory practice

RUBRIC: Measurement of the magnetic field of a small magnet

- ***Context and general conception of the work or activity***

OBJECTIVE:

Definition of the competition: the ability to calculate the dependence on the distance that has the component "X" of the magnetic field of a small magnet, using the magnetic sensor that have incorporated the vast majority of "smart" mobile phones, along with an application that has to be previously installed; analyze and reflect on the development of the practice and use of the smartphone in a Physics lab.

Competency components that want to be mobilized.

- The distance data to the smartphone and the value of the magnetic field x(cm) and B(μT)
- Adjustment by least squares **y = mx + b**
- Value of the exponent **n** of the variable x, correctly expressed with its error
- **μ** value, magnetic moment with its absolute error and units
- Correct realization of the graph **B** versus **x**
- Correct completion of the appropriate logarithmic graph
- Analysis and response to four questions about the smartphone practice

Evidence that will the activity or the evaluation device provide on the development of the competition.

- Data (values) **x(cm)** y **B(μT)**
- Adjustment by least squares **y = mx + b**
- Value of the exponent **n**
- Value of **μ**
- Graphic **B vs. x**
- **Logarithmic** Graphic
- Answers of the 4 questions

- ***Attributes of optimal development grouped around dimensions or components of the work or activity.***

Quality Inventory it should have to demonstrate optimal development.

- Comprehension and observation to be able to take the data.

- Analysis and values calculation.
- Reflection to obtain conclusions.

Organize by dimensions of work or activity.

1: Comprehension and observation for data taking.
- The experimental data acquired in the laboratory **x(cm)** y **B(μT)**

2: Analysis and values calculation
- Adjust by least squares **y = mx + b**
- Value of the exponent **n** of the variable x, well expressed with its absolute error
- **M value**, with its absolute error and units
- Correct completion of the graph **B vs. x**
- Correct completion of the **logarithmic** graph

3: Reflection to obtain conclusions
- Analysis and answer the four questions about the Smartphone practice.

MATERIALS:

- A Smartphone that has the magnetic sensor,
- An application capable of displaying the three components of the magnetic field measured by the magnetometer, installed on the Smartphone
- A rule that allows measuring in centimeters
- A sheet of paper, A4 size
- A fridge magnet (small and powerful)
- A computer
- Excel Program

QUESTIONS ABOUT THE LAB SESSION OF THE SMARTPHONE

1. Why do you place your Smartphone towards the North?
2. Why must the exponent of the variable x be negative?
3. How do you improve this lab session?
4. Which is your opinion about the introduction of Smartphones in the lab Physics sessions?

Once the practice has been completed and after having reflected and answered the four questions, it is necessary to draw up a conclusion that includes: **the impact that the practice has on their previous knowledge, those that have been put in place and those that have been developed to respond to the learning requirements of this activity; in addition, it must be mentioned what has been learned and how it has been learned.**

- ***Scale to assess the level reached in each dimension, category, or indicator and descriptors of each level.***

Level A: Outstanding = Non-modified (value 10).
Level B: Notable = Suitable with some small observation without modifications (value 8).
Level C: Well = Apt with some observation with modifications (value 6).
Level D: Insufficient = Not suitable with important modifications (value 3).
Level E: Very deficient = Not suitable, complete modification of the activity (value 0) or did not present.

This activity has a value of 10 points, which is the maximum grade of this practice. In table 1, the analytical type rubric is shown for the respective evaluation.

Table 1. RÚBRIC ABOUT THE MEASUREMENT OF THE MAGNETIC FIELD OF A SMALL MAGNET

ASPECT OR CRITERIA TO EVALUATE		QUALITATIVE/QUANTITATIVE EVALUATION LEVELS					OBSERVATIONS
DIMENSION	**SUBDIMENSION**	**Level E: Very Deficient Grade 0**	**Level D: Insuficient Grade 3**	**Level C: Well Grade 6**	**Level B: Notable Grade 8**	**Level A: Outstanding Grade 10**	
Comprehension and observation to be able to take the data	Data of the variables to measure **x(cm)** y **B(μT)**	The table does not show any of the 16 values of these two variables: or the assignment was not turned in. (0 points)	The table shows the 16 values of these two variables incorrectly. (0.2 points)	The table shows correctly only 5 values of these two variables. (0.6 points)	In the table, only 8 values of these two variables are displayed correctly. (0.8 points)	The table shows the 16 values of these two variables correctly. (1 point)	
Analysis and values calculation.	Adjustment by least squares **y = mx + b**	The value of the adjustment line by least squares **y = mx + b**, is not displayed or the job was not delivered. (0 points)	Correctly displays only 1 of these values: **m, ε_a(m), b, ε_a(b), r** of the adjustment line by least squares **y = mx + b** (0.6 points)	Correctly shows only 2 of these values: **m, ε_a(m), b, ε_a(b), r** of the adjustment line by least squares **y = mx + b** (1.2 point)	Correctly shows only 3 of these values **m, ε_a(m), b, ε_a(b), r** of the adjustment line by least squares **y = mx + b** (1.7 points)	Correctly shows the 5 of these values **m, ε_a(m), b, ε_a(b), r** of the adjustment line by least squares **y = mx + b** (2 points)	
	Value of the exponent **n**	The value of both the exponent **n** and its corresponding error were obtained, or the assignment was not delivered. (0 points)	Incorrectly obtains the value of the exponent **n**, without calculating the error. (0.4 points)	Correctly obtains the value of the exponent **n**, but miscalculates its error. (0.7 points)	Correctly obtains both the value of the exponent **n** and its error, but expresses them Incorrectly (0.8 points)	Correctly obtains both the value of the exponent **n**, and its error, and correctly expresses it. (1 point)	
	Value of the magnetic moment **μ**	The value of both the exponent **μ** and its corresponding error were obtained, or the assignment was not delivered. (0 points)	Incorrectly obtains the value of the exponent **μ**, without calculating the error. (0.4 points)	Correctly obtains the value of the exponent **μ**, but miscalculates its error. (0.7 points)	Correctly obtains both the value of the exponent **μ** and its error, but expresses them Incorrectly (0.8 points)	Correctly obtains both the value of the exponent **μ**, and its error, and correctly expresses it. (1 point)	
	Graph **B vs x**	It does not show the experimental points or the graph, or the assignment was not delivered. (0 points)	Incorrectly shows the experimental points in the graph uniting them by segments. (0.3 points)	Correctly shows the graph without clearly specifying the experimental points (0.6 points)	Correctly shows the experimental points in the graph, but does not specify the axes (0.8 points)	Correctly shows the experimental points in the graph, with their corresponding axes (1 point)	
	Logaríthmic Graph	It does not show the experimental points	Incorrectly shows the experimental	Correctly shows the **log** graph without	Correctly shows the experimental points	Correctly shows the experimental points in	

		or the **log** graph, or the assignment was not delivered. (0 points)	points in the **log** graph uniting them by segments. (0.6 points)	clearly specifying the experimental points (1.2 point)	in the **log** graph, but does not specify the axes. (1.6 points)	the **log** graph, with their corresponding axes. (2 points)	
Reflection to obtain conclusions.	Answer to the four questions	None of the questions are answered, and there is no conclusion, or the assignment was not delivered (0 points)	Responds specifically only 1 question and the conclusion (0.5 points)	Responds specifically only 2 questions and the conclusion (1 point)	Responds specifically only 3 questions and the conclusion (1.5 points)	Responds specifically the 4 Questions and the conclusion (2 points)	

The interpretation of the evaluation levels are as follows:

- **Level A: Outstanding** = Non-modified (value 10).
- **Level B: Notable** = Suitable with some small observation without modifications (value 8).
- **Level C: Well** = Apt with some observation with modifications (value 6).
- **Level D: Insufficient** = Not suitable with important modifications (value 3).
- **Level E: Very deficient** = Not suitable, complete modification of the activity (value 0) or did not present.

4 CONCLUSIONS

With the implementation of the competencies approach, the aim is to contribute to the improvement of the educational quality, ensuring that the student is competent in his/her area of study and able to solve the problems that arise in the field of employment; it is a student-centered education [13], in which the student integrates five understandings linked with knowledge (know), skills (know-how to do), attitudes (know-how to act), values (know-how to be) and transference (know-how to teach and/or apply).

Knowledge and skills must be assessed and evidenced with the help of objective and transparent evaluation instruments, for example, rubrics; Although, it should also be noted that the rubrics are not a magic wand, but rather, the rubrics are a support and a guide that show indicators, criteria and levels of performance that allow both the teacher and the student, evidence the achievement of goals and skills acquired.

It is also necessary to mention that the effectiveness of this model and of the evaluation depends on the involvement of two fundamental parts in the teaching-learning process, the teacher and the student, since it is a formative and shared system in which everyone must take responsibility and assume their role; because in this type of learning it is about making students more aware of their level of abilities, on how they solve tasks and, above all, what strong points should be empowered and which weaknesses should be corrected in order to cope with future learning situations [14].

The use of rubrics benefits both teachers and students, but the results depend on the people involved in this process, they are the ones who design and use them; therefore, it is considered necessary to evaluate its implementation and results obtained when they are used, as it is proposed in this work. At the end of the next course we will have data to evaluate the usefulness, or not, of this rubric.

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