**** This is a short version of the final paper

Higher level learning outcomes attained through assessment.

The case of the OR course at the Faculty of Engineering of the University of Porto

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Abstract: Bloom's taxonomy for learning domains proposes six categories for the cognitive domain, that go from the basic remembering of facts and definitions to the complex creation act, in which new knowledge structures or patterns are built or new meanings assigned. The Bologna Declaration strained the emphasis on the learning outcomes and on their alignment with the assessment. In this paper a step forward is proposed, in which the assessment process itself has a central role in the attainment of the learning outcomes. A case study of the Operations Research course, involving 350 students from 4 different engineering degrees, is described and conclusions drawn about the effectiveness of this assessment organization in the students' development of the higher level learning outcomes of Bloom's taxonomy.

Keywords: Bloom's taxonomy; assessment; learning outcomes; creativity

Context

The Bologna Declaration and the process that subsequently run in the European higher education system, has put learning outcomes under the spotlight. Given the case study of the Operations Research (OR) course, we will focus on Bloom's taxonomy for the cognitive domain, whose three top categories, "create", evaluate", "analyse", correspond to the high level learning outcomes and represent the biggest challenge for a teacher, both in terms of their definition and assessment.

We will show how OR courses, in the context of 5-year engineering masters, can contribute for the attainment of the high level learning outcomes by means of a well-designed assessment process that makes students aware and creative about real-world problems that can be solved with OR techniques.

Nowadays around 350 students from 4 different engineering degrees go through this assessment process. In the OR course each student has a total of 4 hours of classes per week: two hours of lectures, where the students are divided in groups of around 100 and where lecturing is supported by active learning techniques and other two hours for exercise and practice, with 30 to 35 students, organized in groups of 4, where cooperative learning is promoted.

Assessment

The assessment of the OR course has two main components based on the theme of the year, a real-world theme that will be the context in which the course will be delivered: a final exam that assesses the "analyse" category of Bloom's taxonomy and a continuous assessment that includes a set of exercises done in class and homework cases proposed during the semester.

The exercises, one per week, are designed to be of direct answer and to be solved in 10 minutes and address the "apply" category of Bloom's taxonomy. The homework cases form the second part of the continuous assessment. The aim is to develop creativity and awareness of real-world applications of OR, the "create" category of Bloom's taxonomy. Taking into account the programmatic topic, students are asked to think about a real-world situation linked to the theme of the year, write one page with the description of the problem (data included) and solve it in a second page. In order to frame the difficulty of the technical problem that underlies the case "invented" by the students, some guidelines on the size of the resolution are given. The students are encouraged to seek and use real data and to be creative in the described application as both characteristics contribute to the mark given. Another interesting point is the imposition on a minimum number of iterations or equivalent. Some 13 to 15 exercises and homework cases should be proposed to sum-up 10 points in the continuous assignment. The main idea is that students may fail a few times and still get the maximum number of points, keeping the students involved in the OR course during the complete semester and bringing forward the formative characteristic of this assessment.

Assessing the assessment

It is clearly a time-consuming process, both for the students and the teachers. The question is if this effort is worthwhile. The results are clearly very good. The percentage of students that fail the OR course is very low and the average of the grades is high. A specific survey was run in order to understand how students evaluate the importance for their learning process of the different learning instruments they have available and 81% of the students considered the weekly exercises and homework cases as "very important" or "extremely important" for their learning process.