Evaluating Engineering Competencies: A New Paradigm

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Abstract—The team that has developed this project is part of a consortium of several European institutions that have joined with a common goal: to help the current engineering teaching-learning system, so that to make possible a competencies-based assessment. Moreover advocacy and networking will be part of the consortium activities during the whole project. RULES_MATH acronym corresponds to 'New rules for assessing mathematical competencies', and that is exactly what we propose: to work with the mathematical competencies, specifically try to incorporate them into the assessment process. We focus on science and engineering degrees, since in all these studies several Mathematics courses are part of their curriculum, mainly in the first couple of years. In this paper we present one of our first activities that we want to achieve under the project: the selection of several tools and rules that will make possible an assessment and evaluation according to our high education common European space. These ideas are part of the objectives of promoting and institutionalizing good teaching practices and the enhancement of teaching materials. Other goals are to improve the dissemination of academic activities to the business world, administrations and society in general.

Keywords—competencies; assessment; engineering; mathematics

I. INTRODUCTION

Because of changes in the Engineering Degrees curricula, and according to the guidelines of the Bologna Accord, monitoring student's learning to make them responsible for their learning process, is now required. It is necessary to implement more effectively a system of continuous assessment and competencies-based learning.

Additionally, there are serious difficulties in teaching mathematics to engineering students. One of the big problems is that engineering students use to find difficulties not only in learning mathematical contents but even more in acquiring mathematical competencies and be competent in mathematics. When we teach our Engineering students subjects such as Calculus, Linear Algebra, Statistics, etc, one of our main concerns is usually how we can motivate them to learn mathematics. Engineering students do not often see the relation of mathematics with others subjects, like electricity, mechanics, robotic, automatic, or electronic.

Very often, there are other problems as well: fear of mathematics lessons, finding the relation between mathematics and students future careers. Hence, we want to use realistic big problems in our classes, and solving them with the help of computer-aided tools. This will allows students to understand the true reach of a problem or the effectiveness of an algorithm.

For all those reasons, we consider that this RULES_MATH project (https://rules-math.com/) will have visible impact. Actually, our different groups that participate in the project have already published several papers, with particular examples, where the impact of this competencies-based learning has been measured. See "CAS and real life problems to learn basic concepts in Linear Algebra course" [1], for example. We were conducting a pre-test and post-test survey that includes 13 questions about math learning to different grades of Engineering. The identical pre-test and post-tests have been used to collect quantitative results to measure the advantages of this methodology. We noticed that student's satisfaction raised, and they understood better the relation and importance of mathematics in their real and daily lives or their future work. As a consequence, students participate more often in classes, and their grades were higher than before using these techniques. Some papers related to the project have been included in the special session of EDUCON 2018: "Evaluating Engineering Competencies: A New Paradigm".

Furthermore, the RULES_MATH project provides an opportunity for both students and teachers to be in contact with other teachers and students from other European countries, which means direct contact with other educational systems and cultures. This is the way in which our institutions can work in a multi-cultural framework and share ideas, experiences and

2) *Identification of components* and description of competence-oriented learning activities for the Mathematical competencies.

3) *To share examples* about contents - competencies - maths applications, from partners' experiences and work that has been done.

4) *Identification of educational standards*, and proposal of new rules (a framework) for assessing mathematical competencies.

5) *The analysis and selection of the tools* and software that will be used to create educational resources.

6) *To develop the entire project keeping the quality assurance.* Guide templates will be develop by the quality expert team, in collaboration with all partners (reports, high level analysis and technical design docs, ICT tools and comprehensive short guides for using mathematical and statistical software packages). Material format will also be considered, assuring that all the materials will incorporate a detailed description. The quality guide with the templates and procedures will be available on the project platform.

7) *The ethical approval*, standards or copyright rules will be part of the project process. The proposed development will be subject to ethical approval processes with the relevant academic partner. To check the validity and the Creative Commons License for the files and resources that will be used during the whole project.

V. CONCLUSIONS AND FUTURE WORK

The work of the RULES_MATH project will become a part of the consultancy, training activities and practices provided by the partner institutions who will be interested in their on-going success. The competencies-based standards and resources will be inside a dataset of electronic educational materials in English first (and national languages when possible).

The increasing demand for the development of new computer aided educational solutions, electronic study materials and e-learning facilities will play a crucial role in the process of integration of the project dataset into the internet education scheme. In addition, these centers will provide the most up-to-date information and they will promote usage of ICT as the most advanced platform.

Once established, the RULES_MATH project, we will continue working on it, as we are already working on mathematical competencies. There will be a natural interest from educational institutions to maintain this dataset not only for their own purposes, but also, in the transnational European context, to be informed about the development of the standards, platforms and newly developed educational strategies in mathematics. So, the target groups will be mathematical trainers and learners from engineering degrees from all over the word: at our institutions (in all engineering degrees and we could also add sciences degrees), in other universities from our countries (as this project outcomes will be available on the internet), at EU level (to achieve the goals of a common European higher education area), and to the rest of countries, as the publications of the results will be as papers contributions in international conferences and journals.

The project results will be extended to other interested countries and institutions. New members interested in working within the framework of European institutions will be welcome. They can enlarge the range of available resources and materials, and contribute to solutions for education of mathematics for engineering students at the European level, and they can bring new methods and views on the ways of promoting mathematical competencies and enhanced understanding in the European context. This will help universities to confirm and strengthen their role as leading centers for engineering and life-long learning cooperation with other institutions in the educational and research sectors and other possible sectors (industry, via the Internet at private households for self-learners, including disabled and other disadvantaged people) will contribute to the development of the whole society towards the objectives stated in European policy for the near future.

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