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Changing assessment methods: New rules, new roles [☆,☆☆]

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ABSTRACT

Over the past 20 years, the use of Computer Algebra Systems (CAS) has helped with the teaching of mathematics in engineering schools. However the traditional use of CAS only in math labs has led to a narrow view by the student: the CAS is an additional work, not included in the learning process. The didactic guidelines of the European Higher Education Area (EHEA) propose a new teaching–learning model based on competencies. We suggest the use of the CAS be adapted to the new rules. In this paper, we present a model for the integrated use of the CAS, and we describe and analyze two experiments carried out in the academic year 2011–2012. Our analysis suggests that the use of CAS in all learning and assessment activities has the potential to positively influence the development of competencies.

1. Introduction

The teaching of mathematics has drastically changed in recent years and the current teaching practices differ from what was being done 30 years ago. This change has taken place not only owing to the impact of new technologies in the classroom. There has also been a contribution from the changing legislative framework and the implementation of the educational model adapted to the European Higher Education Area (EHEA) http://www.ehea.info.

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The didactic guidelines of the EHEA propose a new teaching and learning model based on competencies, with new roles for students, who then become the protagonists of their learning. The teachers must guide the students' work and evaluate not only their knowledge and skills but also, above all, their competencies.

The present paper aims to address the problem of knowing the best way of using a Computer Algebra System (CAS) in math teaching in engineering degrees within the framework of competence-based learning as well as the possible contribution of such a system to the process of evaluation of competencies.

Over the past two decades, the use of CAS has become common in mathematics courses within engineering studies and the literature reflects many experiences gained through their use (see Marshall et al., 2012). Artigue (2002) established the theoretical framework of the *instrumental genesis*. According to this theory, the use of CAS involves a process during which the object or artifact is turned into a mathematical instrument. This framework was completed by Drijvers et al. (2009) with the *instrumental orchestration*, for analyzing teaching practices.

The literature also reports experiences in the use of CAS in assessments (see, for example, Thomson et al., 2009). MacAogáin (2002) proposes a model aimed at measuring how CAS affect the solving of the different tasks in an exam. Brown (2001) concluded that *the introduction of CAS into examinations has the potential to allow the student to move away from an examination where the examiner controls the solution strategy to one in which the student control the solution strategy*.

The use of technology is gaining ground in curricula and assessment activities (Meagher, 2000) and it is now being allowed for use in authorities examinations, sometimes without modifying the tasks being evaluated. Brown (2010) analyzed three authorities' examinations and found that the testing of mechanical skills predominated both prior and after the introduction of the graphics calculator.

In recent years the use of CAS has been included in teaching–learning models based on competencies (see Niss and Højgaard, 2011). García et al. (2011a) described how the use of CAS in problem-solving promotes the development of generic competencies.

Here we propose a model of integration of CAS in the teaching of mathematics to engineering students within a learning framework based on competencies that involves their use as an element of constructive learning. This model is the result of our long experience. The theoretical background is based on the instrumental genesis theory (Artigue, 2002) and the toolbox approach (García et al., 2009). We propose the full integration of CAS in all the learning and assessment activities, including examinations. Two experiences, in two different environments, have been carried out, analyzed and discussed.

The paper is organized as follows. First we address general issues, offering a brief overview of the use of CAS and positing the theoretical framework of the model proposed. Then, we describe and analyze the two different experiences obtained after implementing the model. Finally, we offer some conclusions.

2. Learning mathematics and computer algebra systems

2.1. History: twenty years teaching mathematics in a CAS environment

A CAS can be defined as a software with numerical, graphic and symbolic capacities. Its origins can be found in the sixties, with systems such as Reduce, MuMath and Macsyma (see Davenport et al., 1988; Moses, 2012). In this period, the use of CAS was basically reduced to performing mathematical calculations for scientific research. Towards the end of the eighties, CAS such as Derive, *Mathematica*, Maple, etc., began to be used as teaching tools (see Amrhein et al., 1997). Slowly, versions that were easier to use and with better performances led CAS to become an important teaching instrument. Textbooks also began to include examples and exercises using CAS (see Villa, 2011). Around the same time, an interesting debate involving the curricula and CAS teaching methods took place.

Many studies have addressed the teaching of mathematics, above all at the secondary school level, in a CAS environment (see Lagrange et al., 2003). The studies also contain references to the use of CAS as functional and pedagogical tools in university teaching, above all in mathematics courses for engineering students. In Marshall et al. (2012) the authors conducted a comparative study, between