Innovation in the Teaching of Differential Equations for Engineers through Modeling and Technology

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ABSTRACT

The purpose of this writing is to share the experience of an educational practice in a private university in México about a different way to teach a Differential Equations course for future engineers based on a proposal developed by the Math faculty. This proposal emphasizes that Mathematics is a human activity that answers several problems of different nature, and throughout this problem solving activity it is likely that the emergence of mathematical concepts, notions and procedures occurs. Since 2008, innovative material, as laboratory, modeling and simulation practices has been developed for the DE course. Recent research has shown the need to change the way to teach DE, from the "traditional" way, which emphasizes analytical methods, to an integrative mode, (graphical and numerical methods). The student should be capable of integrating technical knowledge with practical skills through modeling. Different learning active environments play an important role in promoting the implementation of the course with hands-on, modeling and simulation activities; and the development of communication, problem solving and modeling skills. Evidence has shown that future engineers achieve better understanding of the math concepts after *living* this educational practice and further develop other skills, as social, communicative, modeling and technological, along with the mathematical.

The purpose of this paper is to share the experience of an educational practice in a private university in the Northeast of México (Tecnológico de Monterrey, Monterrey Campus) about a different way to teach Calculus and Differential Equations courses for future engineers based on a proposal developed by the Math faculty over 14 years (Salinas y Alanís, 2009; Salinas, Alanís y Pulido, 2011). This proposal set off from the idea of re-designing the scholar mathematical discourse present in the Integral and Differential Calculus courses for engineers. It emphasizes that Mathematics is, above all, a human activity that answers several problems of different nature (physical, chemical, biological, etc.), and throughout this problem solving activity it is likely that the emergence of mathematical concepts, notions and procedures occurs.

Students first learn the instrumental aspect of mathematical notions. After proper manipulation, they can theorize about the properties of the objects. This proposal considers that the emergence of mathematical knowledge is significant from the historical and epistemological points of view, and that the teaching of mathematics to future engineers should take into account these stages.

The outcomes of this proposal have been published in the form of four student textbooks –Pre-Calculus, Differential Calculus, Integral Calculus and Multivariable Calculus. The work is still in progress; however, there has been

great advance in the curriculum design for Differential Equations. Since 2008, innovative material (hands-on activities, laboratory practices, modeling and simulation practices, worksheets/spreadsheets) has been developed for the DE course. Its main axis is concerned with the modeling of biological, physical or chemical phenomena.

Recent research has shown the need to change the way to teach DE, from the "traditional" way, which emphasizes analytical methods, to an integrative mode, which uses graphical and numerical methods. This integrative mode should enable students to identify and recognize a DE in its different representations; and thus, improve the learning of DEs as mathematical objects. The student should not only learn how to use techniques to solve DEs but also learn the application of the DE as a tool to model several problems (Rodríguez, 2010). This is also strengthened through the use of specific technology and CAS software such as Maple and Mathematica; simulations, and laboratory practices with sensors in the classroom to better model and understand the phenomenon to study: temperature, an RC circuit, or a spring-mass system. The student should be capable of integrating technical knowledge (DEs) with practical skills through modeling. Different learning active environments play an important role in promoting the implementation of the course with hands-on, modeling, and simulation activities; and the development of communication, problem solving and modeling skills. Since 2010, we have implemented the DE course in the ACE classroom following the North Carolina University SCALE-UP model (Beichner, 2007; Zavala, Alarcón, Domínguez, Rodríguez, 2010). Evidence has shown that future engineers achieve better understanding of the math concepts after *living* this educational practice and further develop other skills (social, communicative, modeling and technological) along with the mathematical.

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