Chapter 2
Using Modeling and Simulation to Learn Mathematics
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ABSTRACT

In this chapter, we present a specific approach on how to teach math through mathematical modeling and simulation. The literature review is presented from the Math Education Community and the advantages for the students using this approach focuses on how to apply Math in their professional lives. We also introduce a framework of reference on using matching technology to help the students make some transitions in the modeling cycle. Several examples from a course in an undergraduate program are shown and we develop some conclusions for basic education and for high school level. Previous research studies developed from a qualitative point of view have helped to demonstrate the potential use of this approach for students to achieve better understanding of this science.

INTRODUCTION

Since the world is changing so quickly, it seems necessary to rethink the working schemes that have been used for a long time. According to different authors (Bourn & Neal, 2008; Fisher, 2011; Rodríguez, 2013; Rodríguez & Bourguet, 2014), the 21st century has brought different demands because we are living in a connected, global world, which needs to build teams with people from different cultures; a natural path follows that leads to rethinking education from various points of view. This paper aims to share an effort being made from the Mathematics Education perspective, especially in the effort of reformulating the intentions of math education to provide training in critical skills that the 21st century citizens require. Thus, it is important to review some key ideas previously pursued on substantially modifying the teaching of mathematics in the classroom by introducing the use of technology and simulation, as well as by incorporating the development of social, communication and teamwork skills in a math course.

From an international perspective, studies such as the Program for International Student Assessment (PISA) report (OCDE, 2009) state the need to train people in developing skills such as mathematical literacy. PISA defines mathematical literacy as the capacity to identify, to understand, and to engage in...
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mathematics and to make well-founded judgments about the role that mathematics plays, as needed for an individual’s current and future private life, occupational life, social life with peers and relatives, and this person’s life as a constructive, concerned, and reflective citizen.

Subsequently, more specific studies (Bourn & Neal, 2008; Jhori 2009) aimed specifically at the population of future engineers, have made explicit the prevailing need that the basic education of an individual considers the fact that they should develop generic skills that complement and reinforce disciplinary skills. In particular, we highlight part of a report (Bourn & Neal, 2008) which aims to develop the global dimension in shaping the future engineer and emphasizes the need and importance of these skills in several areas.

Generic Skills from Bourn and Neal (2008):

2. Active learning and practical application.
4. Strong communication and listening skills.

Hence, the need to develop holistic thinking as an essential skill for students and future citizens of the 21st century is made explicit.

Based on the request of training students of basic education in this area, we decided to explore the importance of the development of the holistic thinking for the future engineers.

Since holistic thinking is also related to Systems Thinking (ST), our proposal is to think how the ST skills can be included from the perspective of math education. Bourn and Neal’s (2008) report mentions the work done by Senge (2006) in this regard and it became the trigger to show the advantages and benefits of incorporating systems thinking in a math class. It is our hope to shed some light on the wealth of integrating the two seemingly disjoint disciplines, Systems Thinking and Mathematics.

Although this study is analyzed from a qualitative paradigm, we have included some quantitative results obtained from an institutional survey. These results are shown only to illustrate the students’ ideas about the course in which we implemented our activity.

First, we introduce highlights of the qualitative approach we followed during 2013. Over that year, we led some interviews and collegiate discussions with an expert in industrial engineering with a minor in electronics. We audited some classes of a specialty course in System Dynamics and analyzed textbooks, technologies, and languages; this made it possible to identify the key aspects of modeling that could be of interest for the future engineer. We decided not to focus on this part about the modeling approach. For more information about previous works in this area, you can review Rodríguez (2013, 2015).

Second, the discussion and the collaborative design of modeling activities for engineers and math teachers (particularly Differential Equations, DE) will be treated in detail. These have allowed setting a series of activities that ask the students to model the reality that surrounds them or to model those which will eventually become part of their everyday working life. All the above considers two aspects: the key ideas of the mathematical part concerning DE, and above all, the modeling practices of future value for the 21st century engineer (Phase 1).

Finally, as a third point, the results of an institutional survey are shown. These set the frame for the qualitative paradigm; it also includes an opinion survey done with the engineering students enrolled in a DE course. The survey dealt with the qualitative paradigm of the implementation of activities through-