Chapter 63
In and out of the School Activities Implementing IBSE and Constructionist Learning Methodologies by Means of Robotics

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ABSTRACT

In this chapter, the authors describe an inquiry-based science education (IBSE) theoretical framework as it was applied to robotics activities carried out in European K-12 classrooms during the last six years. Interactions between IBSE, problem-based learning, constructivist/constructionist learning theories, and technology are discussed. Example activities demonstrate that educational robotics capitalizes on the digital curiosity of young people. This leads to concrete experiences in STEM content areas and spreads computational thinking to all school types and levels. Cooperation among different stakeholders (students, teachers, scientific and disseminating institutions, families) is emphasized in order to exploit in and out of the classroom school resources, competencies, and achievements and for implementing peer-to-peer education among students and teachers in the same class/school or from different schools.

INTRODUCTION

During the last decade, an increasing number of robotics activities for students from kindergarten to high school have been developed for different reasons and often for diverse motivations. For example, the initial goal of the well known Roberta project was to increase the interest in science and technology among girls who were traditionally less interested than boys in these kinds of studies. Bredenfeld and Leimbach (2010) provide an overview of the Roberta experience. Other projects aimed at involving students in scientific and technological activities at an early age often use

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an out of school curriculum like the Kids' Club organized by Sutinen's group at the University of Joensuu, Finland (Sutinen, 2011).

The authors of this chapter carried out different activities with the common goal of using programmable robots for manipulating concepts of the standard school curricula under the influence of the "body-geometry" suggestions in Papert's Mindstorm (1980, p.58). Thus, every activity is a means to capitalize upon the digital curiosity of young people for them to have concrete experiences focusing on discovering or experimenting with concepts of their normal school curricula. All grades from kindergarten to high school have been covered: the first author worked mostly with k-8 students using a mini-language for programming mini robots and an integrated program development environment specifically developed for young people (Demo & Marcianó, 2007; Demo, 2009). The other three authors have been involved in the European TERECoP project, aimed at developing a framework and a community of interest in helping teachers to implement a robotics-enhanced constructionist learning environment in secondary schools (Alimisis, 2009). Most of the activities address the concepts of STEM (Science, Technology, Engineering, and Mathematics) subjects but the interactions of the robotics experiences with other disciplines related to competencies such as native and foreign languages are also investigated.

When the Rocard report was issued in 2007, it suggested an analysis of the relations between its recommendations and the authors' robot activities (Rocard, Csermely, Jorde, Lenzen, Walberg-Henriksson, & Hemmo, 2007). This chapter describes the current state of this analysis. Rocard's report claims that "a reversal of school science-teaching pedagogy from mainly deductive to inquiry-based methods provides the means to increase interest in science" (Rocard, p. 3). It also addresses the connections between inquiry-based science education (IBSE) and a problem-based methodology for mathematical reasoning. As a reference definition of IBSE, for our analysis, we chose the theoretical framework introduced by Yves Chevallard (1999). Rocard's report and Chevallard's framework are addressed in the first section of this chapter with comments on connections among IBSE, problem-based and constructionist/constructivist educational methodologies. In the second section, the authors' robotics activities are illustrated focusing on how they implement Chevallard's IBSE framework mainly because the students discover, record and analyze the facts happening during the robot activities. Experiences for each school level are considered with references to other activities already described in previous papers. The pilot projects are characterized in terms of the level of applicability (from kindergarten to higher-education), IBSE value, and the learning challenge. In kindergarten and the first two grades of primary school, we used the BeeBot, by the TTS-group, in activities where children develop different skills. For example, they are guided to solve topological problems, to experiment with counting and logical thinking and to become accustomed to an inquiry-based learning technique, even in activities related to their mathematical curriculum, which is uncommon in lower grades as reported by De Michele, Demo and Siega (2008). Examples suitable for the middle school level emphasize the goal of supporting the introduction of new important abstractions like variables in algebraic expressions, relative numbers, the dimensional calculation of physics, elementary goniometry (Demo, 2009). In high school the full potential of relative complex robotic architecture can be exploited to introduce a wide variety of new concepts: trigonometry, kinematics and dynamics, rudiments of artificial intelligence, theory of computer science and technology (Frangou et al., 2008; Arlegui, Menegatti, Moro, & Pina, 2008).

The activities attain two main achievements. On the one hand, students become accustomed to an inquiry based science education in designing and implementing robotic activities during school hours where concepts of the normal curricula are introduced or experimented according to an

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