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השפעת מדעי המחשב על למידת פיסיקה בסביבת מדע חישובי

The Effect of Computer Science on Physics Learning in a Computational Science Environment

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Abstract

College and high-school students face many difficulties when dealing with physics principles and concepts, such as a lack of understanding of the components of formulas or of the physical relationships between the two sides of the formulas. To overcome these difficulties some instructors suggest combining design of simulations while learning physics, claiming that the programming process forces the students to understand the physical mechanism activating the simulation. The current research investigated the physics learning taking place while programming physics simulations. In particular, it explored how programming and computer science (CS) affect physics learning taking place in a unique context, a computational-science course where the physics learning was *not* one of the goals of the course thus not extensively addressed.

This study examined the physics learning of computational-science students. It reports on findings obtained from the analysis of the discourse of pairs of students while developing computational models of physics phenomena. The following three learning aspects were examined: (a) The physics conceptual understanding achieved by the students. The students' conceptual knowledge in physics was evaluated at the beginning and at the end of developing the models, and at different stages in between. Concept maps (Novak & Cañas, 2008) were used to represent the students' knowledge. (b) The effect of CS on the evolution in students' conceptual knowledge in physics was evaluated using the Knowledge Integration (KI) framework (Linn & Eylon, 2006, 2011), which describes four thinking processes that students should undergo to experience meaningful learning. (c) The problem-solving (PS) behaviors employed by the students and the effect of CS on them were evaluated using the Epistemic Games framework (Tuminaro, 2004; Tuminaro & Redish, 2007) which describes coherent activities that are used for creating knowledge or solving a problem. (d) The effect of CS on students' ability to think at different levels of abstraction in physics. The framework of Epistemic Games (Tuminaro, 2004; Tuminaro & Redish, 2007) was used for this purpose as well.

Findings revealed that the computational-science students gained physics knowledge that is reported to be difficult for high-school and even undergraduate students. Four different domains that exist in CS were found to trigger physics learning: structural knowledge, procedural knowledge and systemic knowledge that deal with knowledge representation, and the execution domain that enables reflection on the represented knowledge.

The computational environment in general, and CS in particular, was most of the time the trigger of the students' application of high-level PS behaviors. In some cases, however, the difficulty of combining physics with CS led the students to apply low-level PS behaviors.

Moving between levels of abstraction in CS was found to encourage the students to move between levels of abstraction in physics. The need to develop computational models encouraged the students to apply higher levels of abstraction in physics, mainly during the development and exploration of equations. At the same time, students moved

between the higher level of abstraction in CS—developing the interface—and the lower level of activating it as code.

In general, CS was found to affect physics learning in both positive and negative ways. It seems that combining CS and physics was difficult for the students, but it was also the catalyst to effective learning. Instructional implications and limitations of the research are discussed.