Chapter 1
Computer Science Education Research: An Overview and Some Proposals

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ABSTRACT

This chapter aims to present and summarize a variety of research areas that directly or indirectly have influenced Computer Science Education Research, particularly associated to the teaching and learning of programming. It is known that many students encounter a lot of difficulties in introductory programming courses. Possible reasons for these difficulties are discussed and some existing proposals in the literature are presented. Based on this discussion, the chapter also includes a description of work done at the University of Coimbra, trying to define more adequate pedagogical strategies for introductory programming courses. The results obtained and their implementation in a common undergraduate course are presented and discussed. The authors conclude that this new strategy makes learning more stimulating for the students, minimizes dropout intentions, and makes the students learn more and better. The chapter ends with suggestions of future research opportunities within the topic of teaching and learning of programming.

INTRODUCTION

High failure and dropout rates are common in introductory programming courses in many high education institutions worldwide (Jenkins, 2002; Lahtinen, Ala-Mutka, & Järvinen, 2005; Lister, Simon, Thompson, Whalley, & Prasad, 2006). This is a situation that affects mostly novices as those courses are usually placed at the beginning of the curricula (Djisktra, 1989; Lee, Rodrigo, Baker,

DOI: 10.4018/978-1-4666-7304-5.ch001

Sugay, & Coronel, 2011; Lister, 2000). Many causes for the learning difficulties have already been identified (Bennedsen & Caspersen, 2006; Byrne & Lyons, 2001; Carbone, Ceddia, Simon, & Mason, 2013; Cook et al., 2012; Gray, Goldberg, & Byrnes, 2007; Jenkins, 2002; Lahtinen, Ala-Mutka, & Järvinen, 2005; Milne & Rowe, 2002; Stachel et al., 2013). It is possible to argue that difficulties are mainly related with the students' background knowledge, the nature of programming, the learning methods and study attitudes and the pedagogical strategies commonly used in introductory programming courses (Gomes & Mendes, 2007; Gomes & Mendes, 2008; Pacheco, Henriques, Almeida, & Mendes, 2008).

Different solutions have been proposed in the literature, but the situation remains mostly unchanged, as many novices continue to struggle to learn basic programming. Research in this field includes efforts in several areas, from psychological studies to computer-based tools. There are also some well-established journals and conferences devoted to this wide field. Fincher and Petre (2004) made a significant contribution to structure the Computer Science Education Research field, identifying several subareas that in some way orient and give focus to researchers in their studies (Kaufman, 2013; Porter, 2013).

We will also use Fincher and Petre work to organize this chapter, namely when we try to understand the developments on Computer Science Education Research that may help the process of teaching and learning programming to novices. This will be the focus of the chapter in its next section. The chapter progresses with a discussion about the factors, which make it difficult to learn introductory programming, leading to the proposal of some pedagogical principles that have been tested and put into practice with some success at our university. Some views on future trends in this field are also included before the chapter conclusion.

BACKGROUND ON COMPUTER SCIENCE EDUCATION RESEARCH AREAS

Research in education (teaching and learning) in computer science now covers a wide variety of topics. In order to explore issues related to the teaching and learning of programming, we must first situate them in the broader Computer Science Education Research area. We start with an overview of related research, structured according to the main research subfields defined in the book Computer Science Education Research, edited by Sally Fincher and Marian Petre (2004). In this book, the authors identified several major areas concerning education in computer science. Although the areas are not disjointed, this classification can be a useful tool for a better positioning when investigating a topic related to the teaching/learning of computer science. The mentioned areas are: Student Understanding; Animation, visualization and simulation; Teaching methods; Assessment; Educational Technology; Transferring professional practice into the classroom; Transferring from presence education to distance education; Recruitment and retention; Construction of the discipline.

Student Understanding

Research conducted in the student understanding area focuses mainly on the mental and conceptual models that students have about a particular subject matter and their conceptions and misconceptions about it. Many of the studies in this area try to understand why students have problems with a particular topic, concept or construction. Also in this area there are various studies related to skills, behaviours and attitudes that distinguish good students from poor students. The differences in terms of understanding and awareness between beginner students and experts are therefore objects of study in this area. The range of investigated topics is also vast and may include broader topics such as