

# Is Pair Programming More Effective than Solo Programming for Secondary Education Novice Programmers?

## A Case Study

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### ABSTRACT

The teaching and learning of programming are often considered a difficult topic for both teachers and students, due to its complexity and abstract nature. The traditional teaching approaches are unable to contribute substantially to the development of the necessary cognitive models by the students, producing high rates of failure and dropout in introductory programming courses. In the last 30 years, the scientific community has not stopped looking for new pedagogical approaches and teaching techniques in introductory computer programming courses. Various studies have shown that pair programming under appropriate conditions may create an environment conducive to learning, leading to an increase student interest in programming. In this paper, the author presents the results of a pilot teaching intervention. The sample was collected among first-grade students of a high school in Greece. The results showed that the pair programming is more efficient than the solo programming, both on facilitating and supporting students' learning and understanding of basic programming concepts, as well as on improving students' attitudes toward programming.

### KEYWORDS

Introductory Programming Courses, Novice Programmers, Pair Programming, Secondary Education, Solo Programming

### INTRODUCTION

Over time, introductory programming courses are considered particularly demanding by the students, resulting in either low improvements in measures of student performance or high dropout rates of students (Anfurrutia, Álvarez, Larrañaga & López-Gil, 2016). As almost all traditional teaching approaches are unable to contribute substantially to the development of students' cognitive skills for the understanding of basic programming concepts (Jimoyiannis, 2013), the adaptation of new teaching approaches and techniques is a topic of concern in the international research community (Papadakis & Orfanakis, 2017).

A technique which has been popularized in recent years in the software industry, the pair-programming or collaborative programming, gradually is gained wide publicity in the education sector, as it can be effectively used for novice programmers in introductory programming courses. According to this technique, two novice programmers working together on a single computer for the completion of a program (Cockburn, & Williams, 2000). Surveys conducted at a university level have highlighted its potential as an effective technique in terms of increasing student performance and

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reducing dropout rates (Williams & Kessler, 2001). On the contrary, there are only a small number of relevant studies in secondary education (Denner, Werner, Campe & Ortiz, 2014).

The paper is structured as follows: we will first describe in detail the problems commonly faced by novice programmers and the various research efforts to address those problems. The next section is devoted to a detailed presentation of the pair programming method and examples of the application of this method in secondary and tertiary education are given. Particular reference is made to the role of the teacher for the successful implementation of this method. The section entitled “The study” contains a detailed description of the teaching intervention, while the paper concludes with the presentation of the intervention and the conclusions stem from the present study.

## **NOVICE PROGRAMMERS**

Although programming, in general, can be used as a “mindtool” to help students in using modern technologies to solve problems (Jonassen, 2000), teaching and learning of programming are considered a difficult task both for teachers and students (Ivanović, Xinogalos, Pitner & Savić, 2016). High dropout rates and unstable attendance are common in introductory programming courses (Bennedsen & Caspersen, 2007; Hanks, Fitzgerald, McCauley, Murphy & Zander, 2011). There are clear indications that the traditional teaching approach both in universities and in secondary education is ineffective (Jimoyiannis, 2013) as there is a multitude of research data which show that the novice programmers have serious problems understanding even the basic programming concepts (Anfurrutia et al., 2016; Williams, McCrickard, Layman, & Hussein, 2008).

The difficulties faced by novice programmers in learning to program are well documented and are identified in the use of variables, logical operators and control structures, the loops, passing the values and running multiple threads simultaneously (Meerbaum-Salant et al., 2013). Novice programmers often fail to correctly apply the knowledge they have obtained (Ala-Mutka, 2004). Students may know the syntax and semantics of individual statements, but they do not know how to combine those elements in order to produce valid programs (Costa, Aparicio & Cordeiro, 2012). Students commonly have misconceptions concerning the creation of a program, such as variable initialization, loop conditions, indicators, data structures and recursion (Robins et al., 2003). They face similar problems with object-oriented programming paradigms (Guzdial, 2004).

Over the last three decades, several research efforts and educational approaches have focused on the improvement of the learning process and the context of the learning process in introductory programming courses. The efforts are related to the choice of an introductory programming language, the potential strategies on how to approach the basic programming concepts (objects-first, structured-first), the use of editors, programming environments, and specialized tools such as microworlds, educational games, visualization tools etc. (Ivanović et al., 2016; Williams, et al., 2008). The innovative teaching approaches are built on pair-programming, exploratory learning, “black box” approach, as well as the approach based on “investigations” (Hanks et al., 2011).

## **PAIR PROGRAMMING**

The pair programming or collaborative pair programming is a software development technique whereby two programmers work collaboratively to implement a software project (Hanks et al., 2011; Lui & Chan, 2006). It is also known as “pairing”, “paired programming” and “programming in pairs” (Agile Alliance, 2017). Pair programming consists of two programmers sharing a single workstation (one screen, keyboard, and mouse among the pair). The programmer at the keyboard is usually called the “driver”, the other, also actively involved in the programming task but focusing more on overall direction is the “navigator”; it is expected that the programmers swap roles every few minutes or so (Agile Alliance, 2017).

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