Editorial
Computational Thinking

Francisco José García-Peñalvo

***Abstract*— Information technologies are the base of the world infrastructure. In this social context, education, like any productive or service sector, is affected by technology. Faced with this reality, educational systems must prepare our young people to live in the digital world, for which they must be proficient in a new language without which they will become digital illiterates. Therefore, in school we should not only train in linguistic and numerical literacy, but also in digital literacy. So far, the effort has been oriented mainly to convert our young people into users of computer tools. This has gone from being necessary to being insufficient, because the use of software applications means to manage a digital language that is obsolete in a time that is not proportional, in effort, to the time that has been invested in acquiring these skills. Therefore, the challenge is to prepare our young people to face the world in which they live, giving them the necessary cognitive tools to succeed in the digital world. That is, instead of teaching students only the syntax of a changing language, they should be instructed in the rules that allow them to know how the digital language is constructed. Thus, computational thinking emerges as a paradigm of work, and the programming is stablished as the tool to solve problems.**

***Index Terms*— Computational thinking, teaching of computer science, programming, pre-university studies, university studies.**

I. Introduction

THE social context in which we currently live is completely linked to technology. Faced with this reality, the educational debate has to be modified and must go from being based on being technology users, to finding a solution for our young people to master the new digital languages [item 1) in the Appendix] that govern the society in which they were born and they will have to develop as professionals in the near future.

This education related to Computer Science must be understood in the two dimensions: computers in education and computer science education [item 2) in the Appendix]. Until now, the effort has been mainly oriented to convert our young people into computer tools users. This has gone from being necessary to being insufficient, because the use of software applications is a digital language that becomes obsolete at a time that is not proportional, in effort, to that which was invested in acquiring the skills.

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This concern for education in computer science started at an early age. Even in nursery level, this concern appears internationally and has been channeled mainly teaching children how to code.

This debate on computer science education at non-university levels is in all social actors related to Computer Science and there are many initiatives in this regard.

Aware of the importance of digital skills (eSkills) related to information technologies and the need to include Computer Science in the curricula of non-university levels, the Spanish Conference of Directors and Deans of Informatics (in Spanish *Conferencia de Directores y Decanos de Ingeniería Informática* – CODDII – www.coddii.org) and the Spanish Association of University Teachers in Computer Science (in Spanish *Asociación de Enseñantes Universitarios en Informática* – AENUI – www.aenui.net) have been undertaking joint actions in this regard for years. One of the first was the writing in 2014 of the declaration "For the inclusion of specific subjects of science and computer technology in the basic studies of secondary and high school education" [item 3) in the Appendix].

In addition, in 2015 the Scientific Information Society of Spain (in Spanish, *Sociedad Científica Informática de España* – SCIE –www.scie.es) created a working group (set of SCIE, CODDII and AENUI). Because of the work of this group, the workshop "Education in Computer Science under 18 (EI <18)" (http://www.congresocedi.es/ei-18) was organized within the framework of the V Spanish Congress of Computer Science (in Spanish *Congreso Español de Informática* – CEDI – http://www.congresocedi.es), which was held in Salamanca, Spain in September 2016. Due to the celebration of the CEDI Conference edition at the University of Salamanca, the GRIAL research group (GRoup in InterAction and eLearning – http://grial.usal) joined the Organizing Committee, contributing with its proven experience in the subject with international projects such as TACCLE 3 – Coding (http://www.taccle3.eu) [item 4) in the Appendix]. As a continuation of this work and to record documented good practices, both those presented in the workshop and others that could not be presented due to time constraints, two special issues in scientific journals were published with the specific aim of education in Computer Science in pre-university contexts [item 5) in the Appendix], [item 6) in the Appendix].

There are also other initiatives from different publications that have dedicated special issues to the subject of computational thinking. This is the case of issue 46, September 2015 of RED (Journal of Distance Education – http://www.um.es/ead/red/red.html), which is devoted entirely to the topic of "Computational thinking" [item 7) in the Appendix] or, more recently, in volume 80 (2018) of the Computers in Human Behavior journal the special section entitled "Exploring the computational thinking effects in pre-university education" [item 8) in the Appendix]. In addition, computational thinking is a topic that is beginning to be a prominent topic in different international conferences. For example, in the 2016 and 2017 editions of the TEEM International Conference (Technological Ecosystems for Enhancing Multiculturality – http://teemconference.eu/) specific sessions were organized related to this topic that led to extremely interesting and fruitful debates, and at the XVIII International Symposium on Educational Informatics (SIIE 2016) there were contributions enough to organize a thematic session.

In the background of all this debate lies the idea of how to deal with this education in Computer Science and programming, especially in pre-university studies. On the one hand, there are initiatives that focus on programming, using visual or non-visual languages as a way to introduce young people in Primary Education, fundamentally, and in Secondary Education levels into Computer Science. On the other, there are initiatives based on the idea of computational thinking [item 9) in the Appendix], [item 10) in the Appendix], with the idea of having a way of solving problems based on computational principles, but without necessarily having to carry out computer programs. This means that instead of teaching them only the syntax of a changing language, they should be instructed in the rules that allow knowing how the digital language is constructed [item 6) in the Appendix].

Both ideas are clearly compatible and easily integrated in any strategy, since computational thinking can be based on programming [item 11) in the Appendix], robotics [item 12) in the Appendix], control of devices [item 13) in the Appendix], wearables [item 14) in the Appendix] or simply unplugged concepts [item 15) in the Appendix], that is, without any technology and aimed at developing a way to solve problems. Contrary to the approach of computational thinking is the opinion of those who say that there is no clear consensus in its definition [item 16) in the Appendix] and bet on the concretion that gives the development of applications using programming languages.

Experience tells us that there is no miracle solution to solve a problem as complex as trying to explain the internal logic that governs the functioning of the digital world. From this editorial, it is proposed and defended that we must walk towards a critical and reflective education immersed in a digital world, which helps young people to solve problems by using the technology with which they live daily. For this, teachers have a rich range of possibilities with which to create scenarios and learning activities that are effective by combining the tools and methodologies available to them: computational thinking, programming, robotics, teamwork, critical thinking, etc. [item 8) in the Appendix].

In addition, computational thinking has application in multiple contexts (pre-university and university) and formats (combining face-to-face, online or mixed environments).

In short, the teaching of programming and computational thinking, both at pre-university and at university levels, is a topic of interest for IEEE RITA, which has led to the organization of this special section that includes 4 papers.

In the first one, entitled *Computational Thinking between Philosophy and STEM. Programming Decision Making applied to the Behaviour of "Moral Machines" in Ethical Values Classroom*, describes a learning activity that uses computational thinking in an ethics class for students aged 14 to 16 with a STEM approach (Science, Technology, Engineering and Mathematics). Specifically, it addresses a problem of reflection on the moral machines that must make decisions that can affect human lives.

The paper *Learning scenarios for the subject Methodology of Programming from evaluating the Computational Thinking of new students* presents a proposal to evaluate the computational thinking of new students of the Information Technology and Communication division of the Technological University of Puebla to relate the knowledge indicated in the subject "Programming Methodology". Students are offered an initial learning environment where they can prove, review or learn what the test determines in order to motivate the students.

In the paper *"Evolution": Design and implementation of digital educational material to strengthen computational thinking skills*, the authors describe how a digital resource supports the improvement of skills in the development of algorithms within Math problems. This belongs to a part of operative computational thinking, and it is taught to students of the subject Logic Programming.

The last paper, entitled *A Methodology Proposal based on Metaphors to teach Programming to children*, proposes a methodology based on applying metaphors, such as recipes (for programs and sequences) or boxes (for variables), to the teacher's resources devoted to teaching programming to 9-11 aged children.

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Appendix
Related Works

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4) F. J. García-Peñalvo, "A brief introduction to TACCLE 3—Coding European project," in *Proc. Int. Symp. Comput. Edu. (SIIE)*, Sep. 2016, pp. 1–4.
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12) C. Fernández-Llamas, M. Conde, F. J. Rodríguez-Lera, F. J. Rodríguez-Sedano, and F. J. Garcí-Peñalvo, "May I teach you? Students' behavior when lectured by robotic vs. human teachers," *Comput. Hum. Behav.*, vol. 80, pp. 460–469, Mar. 2018.
13) P. Martín-Ramos *et al.*, "First exposure to Arduino through peer-coaching: Impact on students' attitudes towards programming," *Comput. Hum. Behav.*, vol. 76, pp. 51–58, Nov. 2017.
14) D. Reimann and C. Maday, "Enseñanza y aprendizaje del modelado computacional en procesos creativos y contextos estéticos," *Edu. Knowl. Soc.*, vol. 18, no. 3, pp. 87–97, 2017.
15) T. Bell, I. H. Witten, and M. Fellows, "'CS Unplugged. An enrichment and extension programme for primary-aged students. Version 3.2.2," CS Edu. Res. Group, Univ. Canterbury, Christchurch, New Zealand, 2016.
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