Current trends in robotics in education and computational thinking

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ABSTRACT

Computational thinking-related issues have had a specific track on TEEM Conference since 2016. This is the sixth edition of this track within the 2021 TEEM Conference edition. This year the papers are centered on programming and robotics, but the artificial intelligence topics increase their presence in the track.

CCS CONCEPTS

• **Social and professional topics** → Professional topics; Computing education; Computational thinking; • **Computer systems organization** → Embedded and cyber-physical systems; Robotics.

KEYWORDS

Computational thinking, robots, coding in schools, computational thinking skills and curriculum, programming, computer science in K-12, STEM, STEAM

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1 INTRODUCTION

The concept of Computational Thinking (CT) became popular about fifteen years ago with Wing's famous paper in 2006 [1]. The CT is mainly rooted in pre-university education [2], from kindergartens [3, 4] to secondary education [5, 6], with significant success in primary education [7–9]. The CT is also considered in university education, but not with the same emphasis as in pre-university levels [10–12]. CT skills have been developed with technology, using robots [13–15], makers [16–18], and programming languages [19–22], and without technology throughout the CT unplugged approach [23–25].

The main issue with the CT concept is the lack of a precise definition of CT. There are many CT-related literature reviews [26, 27], but there is no consensus on the definition. Moreover, many contradictions and misconceptions are derived from the different CT approaches [28, 29], mainly because the CT does not belong or is not associated with any specific subject.

Beyond the pedagogical reasons to enhance skills related to logical thinking and problem solving through CT [30], there is a clear commitment to educate future citizens in the basic knowledge of computer science as a science and technology [31, 32], beyond a mere digital literacy (DL) [33, 34].

However, there is a lack of national strategy in most countries to guarantee students achieve this aforementioned basic knowledge in computer science. This situation is derived from quick policies [35] that are not the best way to face the challenges we will have as society soon regarding technology and digital transformation [36, 37].

From its first edition of this track at TEEM Conference in 2016 (and with the 2021 edition, there are now six editions of this track [38–42]), the objective is to encourage discussion to define the limits and usefulness of CT while defending the teaching of the basics of computer science in the context of a specific subject [43].

Besides, this CT-related track also gives visibility to research projects that develop CT skills in STEM (Science, Technology, Engineering, and Mathematics) [44, 45] and STEAM (Science, Technology, Engineering, Arts, and Mathematics) [46, 47] contexts such as for example TACCLE3 coding [48], VALS [49], W-STEM [50] or RoboSTEAM [51].

2 TRACK ORGANIZATION

Eight papers have been accepted in this track. The COVID-19 [52–54] definitely marked and conditioned the TEEM 2020 edition. In this 2021 edition, COVID-19 is still present; however, a hybrid edition is organized, allowing both presential and virtual participation of the authors.

The accepted papers are briefly presented in the following sections.

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2.1 Interweaving Digital Literacy with Computational Thinking

George-Reyes et al. [55] analyze and discuss the relationship between CT and DL in a framework where technology is used for education, designing a conceptual proposal that shows its common elements. The result is an initial proposal of interweaving that addresses skills such as abstraction (critical/cognitive-informational-communication), algorithm design (critical/cognitive-informational), and communication as standard components.

2.2 A Tool Help for Introductory Programming Courses

Figueiredo and García-Peñalvo [56] present a tool to help the teaching and learning introductory programming, so called HTProgramming. The results of the usage of this tool in the teaching context are also introduced. The authors apply a predictive model of machine learning (neural network) of student failure based on the student's profile. The resulting tool allows teachers to effectively track the entire teaching and learning process and early identify students that are most likely to fail, allowing them to devote more time to those students and try new strategies to improve their programming skills.

2.3 Specific Didactic Strategies Used for the Development of Computational Thinking in the Female Collective in Primary and Secondary Education: A Systematic Review Protocol

To make a good Systematic Literature Review (SLR) [57, 58] it is mandatory to define the right protocol to follow the review workflow [59]. Torres-Torres et al. [60] define a systematic review protocol aimed at identifying the different strategies in the teaching and learning of computational thinking from a gender perspective, generating an alert regarding the needs of the female group in learning computational thinking and promoting gender-equitable education in this regard.

2.4 Demonstrative educational haptic manipulator robot: A teaching aid in Mechatronics

Pereira et al. [61] present an educational experiment, that consists of a mechatronic system applied to demonstrate concepts such as prototyping, control, haptic feedback and the use of different sensors and actuators. The already existent prototype was modified with the necessary changes to fulfill the requisites of the proposed system, being included load cells to provide measurement of the applied forces, and the robot gripper was also modified, being applied an electromagnetic actuator.

2.5 Scenarios of the use of robotics as a support tool for teaching

Lopez-Caudana et al. [62] show the results of approaching robotics as a support in mathematics classes, in various educational scenarios in Mexico, resulting in favorable ideas and experiences for the motivation of students, as STEAM education tools.

2.6 RoboSTEAM project the pilot phases

Conde et al. [63] presents the results of the pilots of the RoboSTEAM European Project [64], which have been affected by the COVID-19 pandemic [65]. The application of Challenge Based Learning and Physical Devices and Robotics facilitate the so named twenty first century skills. The results show that there are important differences between partners socioeconomical context, but that the outcomes of the project are flexible enough to be applied successfully in any of them.

2.7 Using Educational Robotic Exoskeleton for the Acquisition of Cross-Curricular Competences in Higher Education

Lozano-Arias et al. [66] have designed a prototype of a low-cost and open-access exoskeleton that can be used in different engineering degrees for the acquisition of cross-curricular competences. They also propose to use it in a practice to be carried out in the laboratory following the project-based learning methodology from a STEAM approach. With the use of a robotics kit and a project-based learning methodology, authors achieve the goals of educational robotics and computational thinking in a higher education environment.

2.8 Visualization tool for teaching and learning Artificial Neural Networks

Mrong et al. [67] describe a visualization tool for teaching and learning the basics of artificial neural networks with a user interface and a mobile robot. The study suggests that visualization tools can increase interest in teaching and learning certain topics regardless of its complexity. It also suggests that similar tools can be utilized in teaching topics related to Artificial Intelligence.

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