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COMPUTATIONAL THINKING AND AI: TWO IRRECONCILABLE WORLDS?

Rafael Zerega[1]*and Marcelo Milrad[2]

[1]*Department of Computer Science and Media Technology, Faculty of Technology, Linnaeus University, Sweden, rafael.zerega@lnu.se*
[2]*Department of Computer Science and Media Technology, Faculty of Technology, Linnaeus University, Sweden, marcelo.milrad@lnu.se*
(*Main presenter and corresponding author)

ABSTRACT

Introduction:
We live in a technological society where computerized systems are having a major impact in many aspect of our daily lives. Computers are for the most part ubiquitous and they are powerful tools that can help us in a wide range of fields and tasks. Computational Thinking (CT) is a thought process and an approach to problem-solving that has been gradually incorporated in the educational curriculum of K-12 in different countries around the world during that last decade, as it is considered an approach that helps students develop so-called 21st century skills. However, in recent years, the sudden increment in the use of AI-based systems such as autonomous vehicles, digital assistants and ChatGPT, to mention just a few, has triggered a substantial interest in bringing knowledge of AI to the classrooms. Different systems such as free access web-based educational tools have been developed as many teachers want to impart basic knowledge of AI among their students. Projects like AI4K12 (ai4k12.org) are focusing on teaching AI in K-12 education and to do so, the so-called *Five Big Ideas in AI* have been proposed (Touretzky et al., 2019), which are aimed at facilitating the teaching and learning of AI concepts among K-12 students.

Problem description:
Different authors have been advocating for the inclusion of AI-related matters in K-12 computer education (Garcia et al., 2019; Touretzky et al 2019; Tolvonen et al., 2020; Tedre et al., 2021a; Tedre et al., 2021b). However, AI technology has some fundamental differences from traditional rule-based programming that is usually taught in schools. Therefore, it is important to analyze the challenges of effectively imparting AI knowledge in K-12 and to what extent can traditional CT concepts help to develop AI-related knowledge. There are two research questions guiding this study: (1) what is the interrelation that exists (if any) between CT and AI?, and (2) how can we understand this interrelation in the context of AI education in K-12?

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Method:
In order to address the research questions mentioned in the previous section we conducted a limited scope literature review to try to find some clues regarding the interrelation that exists between CT and AI. The search for literature was made in three databases: Web of Science, IEEE, and Google Scholar. For this study we did not use a single search prompt because we were using different databases and we needed to explore two different topics. Thus, the main searching terms used in this study were "Computational Thinking concepts", "CT concepts", "Artificial Intelligence", "AI", "K-12" and "Education". After cheking the articles' abstract, a total of 31 articles were included for this study. The main goal was to analyze in which way CT concepts underlie the five ideas in AI defined by AI4K12. To do so, we take in consideration the main CT concepts and practices defined by Brennan and Resnick (2012) and Grover and Pea (2018) as they are among the most cited articles that provide a classification of CT concepts and principles. Also, we reviewed the literature to find fundamental differences between CT and AI concepts.

Results and discussions:
The vagueness of the definitions regarding CT is an issue that has already been mentioned by some authors (Selby & Woollard, 2013) and this fact can also be noticed when analyzing CT concepts and practices. For instance, the computational concepts and principles defined by the two authors (Brennan & Resnick, 2012; Grover & Pea, 2018) are partly different. Some of them are even listed in the opposite category (e.g. Brennan & Resnick categorize abstractions as CT practices whereas Grover & Pea categorize them as CT concepts). However, regardless the relative vagueness of some of the definitions related to CT, when considering the five ideas of AI proposed by AI4K12, one can find that there are CT concepts and practices underlying at least four out of the five ideas of AI. For example, AI idea #1 refers to the ability of AI systems to perceive the world through sensors. This idea is closely related to computational concepts such as "data" and "automation". Similarly, AI idea #3 refers to the ability of AI systems to learn from data. A CT concept closely related to this idea is "pattern recognition" as a data-driven AI system is able to find patterns among the large amount of data that has been collected. The fact that relevant CT concepts are the underlying principle of most of these AI ideas suggests that having CT knowledge is a clear advantage when teaching and learning how AI technology works. Only the AI idea #5 does not have any clear underlying CT concept, as it is mainly related to more sociotechnical aspects.

It is also important to realize that although there are several concepts of the classic CT underlying AI concepts, there are indeed some fundamental differences between these two worlds. Some authors argue that traditional CT concepts based on stepwise algorithmic thinking are not enough for explaining data-driven AI technology. Zeng (2013) advocates for a paradigm shift from CT to AI thinking. In a similar fashion, Tedre (2021a) advocates for an update of classic CT to develop what he calls CT 2.0. Based on the reviewed literature we identified four major differences that exist between CT and AI., suggesting the necessity of introducing new CT concepts to address AI technology.

Lastly, we identified some important challenges when connecting CT to AI so that they can complement each other in a meaningful way, for instance, understanding the role of AI as a tool that can help students become better problem solvers and figuring out how to use CT knowledge to try to understand the way in which AI technology has been constructed.

The contribution:
The main contribution of this study is to analyze the interrelation that exists between CT and AI in the context of K-12 education as this is a topic that has just started to be studied. The efforts focused mainly on trying to examine to what extent CT knowledge can help explain AI technology as well as trying to identify which are the main differences between these two worlds. Also, the intention with this work was to reflect on some relevant issues regarding the incorporation of AI matters in the educational curricula in an effective and sustainable fashion, connecting it in a meaningful way with the CT knowledge that many students already possess. Lastly, this study aims at highlighting the need for more studies in this area.

Keywords: AI, computational thinking, computational concepts, K-12, education.

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