Invited Commentary

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Just Using Computers for Any Subject is Not Enough to Acquire Computational Thinking in Early Childhood Education

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Children around the globe are being raised in environments that are saturated with smart devices. Consequently, *teaching computer science at schools is almost universally accepted*, with most countries moving towards its inclusion in the curriculum, even as of kindergarten (Bers, 2019; Bers et al., 2019).

One apparent reason for this educational decision is technology alphabetization: computing is a new literacy for the 21st century (Bers, 2019). Another reason is the *change in the way of thinking about how to solve problems, that is, how we acquire computational thinking* (CT). CT is defined as "... the thought processes involved in formulating problems and their solutions so that the solutions are represented in a form that can be effectively carried out by an information-processing agent" (Wing, 2011). CT includes at least four skills: a) breaking down a problem into easy steps; b) pattern recognition; c) abstraction; and d) the design of algorithms – understood as a series of steps to follow.

Those CT skills are linked – even overlapped – to a group of skills that are crucial for cognition, especially in early childhood: executive functions (EFs) (Robertson et al., 2020). *EFs are a group of cognitive processes that inhibit and manipulate thoughts and actions*, leading to goal-directed behaviors, especially when learning something new. There are three basic EFs (Miyake et al., 2000): inhibitory control (resisting habits, temptations, or distractions), working memory (mentally holding in mind and manipulating information), and cognitive flexibility (switching between mental sets).

It is easy to perceive the overlapping between definitions of EFs and CT. As some authors have pointed (Robertson et al., 2020; Myers, 2021), conceptual analysis of the processes involved in CT indicates that it requires cognitive regulation aspects of EFs. For example, breaking down the problem into easier steps requires holding in mind the whole problem while you separate it into parts. Inhibition is required to not get distracted by details when oneself recognizes patterns or abstracts problems. Finally, flexibility is demanded to change the mindset between a series of steps and select the best option to build an algorithm. Also, the fact that EFs predict academic achievement (Moffett & Morrison, 2020), including the development of mathematical skills and science learning (Cragg & Gilmore, 2014), as well as the evidence showing that educational robotics activities improve EFs (Di Lieto et al., 2020), suggests that EFs are required in CT.

Although the promotion of CT and EFs are desirable aims for early childhood education, there is no agreement in the educational community about how CT should be taught. One of the debate points is *whether to teach CT through general computer use or computer programming* (Denning, 1989). The debate has important practical consequences: if the use of computers for any objective vs. the use of computers to learn programming favors child CT (or EFs) to the same degree, there would be no need to introduce programming concepts in school curricula: it would be enough to use computers for teaching any subject (e.g., history, art, natural sciences), in order to acquire CT skills.

Although not directly designed to address this question, *recent data can indirectly shed light on the issue*. In a cluster-randomized controlled trial (Hermida et al., 2022), five-year-old classrooms were assigned to a study group (which received programming instruction) or a control group (which received art instruction). The classroom's teachers carried out activities with both groups, including tablets – this is a key point. All children were administered a wide battery of computerized EFs tests before and after the implementation of programming or art activities. Preliminary results showed that programming activities increased children's EFs significantly more than the control group. Thus, it is not the same, at the cognitive level, using computers to teach art as to teach programming because only the programming activities (and not the art activities) improved EFs. In sum, if we want to teach CT, a skill that everyone should have (Bers, 2019; Wing, 2011), and favor the cognitive processes linked to that skill, *the mere use of computers is not enough: we need to use computers specifically to teach computer science contents.*

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