

THE IMPORTANCE OF COMPUTATIONAL THINKING IN EDUCATION TODAY. REFLECTION AND RESEARCH: THOUGHT, INTELLIGENCE AND COMPETENCY

L'IMPORTANZA DEL PENSIERO COMPUTAZIONALE NELL'EDUCAZIONE DI OGGI. SEGMENTI DI RIFLESSIONE E RICERCA: PENSIERO, INTELLIGENZA E COMPETENZA

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ABSTRACT

Since the year 2006, when Wing introduced the term “computational thinking”, it has become a topic of educational debates. Wing is also attributed with having represented a first definition. What we mean by “computational thinking” is the “set of mental processes used to formulate problems and their solutions in such a way that the description of the solutions is actually executable by an agent that processes information” (2006); processes which possess a high educational potential

Da quando nel 2006 Wing introdusse il termine *Computational thinking*, il pensiero computazionale è entrato all'interno del dibattito educativo. Allo stesso Wing è quindi concesso offrire i natali per una prima definizione. Per *Computational thinking*, si intende “l'insieme dei processi mentali usati per formulare i problemi e le loro soluzioni in modo tale che la descrizione delle soluzioni sia effettivamente eseguibile da un agente che elabora informazioni” (2006); processi, che possiedono un elevato potenziale educativo,

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Introduction

Computational thinking has been a frequent debate in the past half century, since when, back in 1980, the South African mathematician and computer scientist Seymour Papert, introduced such term in his renowned book *"Mindstorms"*. This idea was then picked up again in 1996, in an article regarding the teaching of mathematics through software tools (Chioccariello, 2013).

In *"Mindstorms"* (1980), Papert outlines the concept of procedural thinking, defining the latter as man's way of thinking which interacts with the computer.

However, the scientific impact triggered by Wing, who reinforced her research two years later with her paper *"Computational thinking and thinking about computing"*, extended scientific interest to other fields including education and for example, the effect that the same computation thinking has on the learning process.

In no time computational thinking became a source of reflection – which was not always favorable – on what are the dogmas that monitor cognitive processes, thus releasing from the control of the computer domain.

This epistemological outspread led to a multitude of definitions, such that it was difficult to achieve a distinct approach.

The polysemantic and interpretative nature emerges directly from the scientific magnifying glass with which it is analyzed, starting from the same concept of thought, which applies to philosophical knowledge, or regarding the description of intelligence, which invokes various psychological and taxonomic speculations, but also in its meaning of competence, which calls into question educational knowledge.

1. Computational thinking as an integrated process

In 1966 Polanyi defined computational thinking as "the unification of mental and cognitive abilities obtained through the study and practice of computer science". If, on the one hand, this definition highlights the origin of the techne of computational thinking, on the other hand it faintly outlines what it actually entails, since it combines together a number of abilities and actions.

If this definition is expanded, one could affirm that it leads to a linguistic "forma mentis", and that it can be utilized as a tool and a methodology for certain purposes.

It is not a matter of trying to find the correct strategies for teaching computer science, but rather it seems that computational thinking is directed towards wider horizons.

The Literature that embraces computational thinking as a transversal knowledge or ability, falls within this sense.

However, this classification should not minimize what is the distinctive element of computational thinking, that is computer science. Therefore, without any doubt, it

is unquestionable that to teach “computational thinking” one must use computer tools: after all, mathematical thinking is taught through mathematics, linguistic thinking through language, hermeneutic methods are taught by analyzing events, and so on and so forth.

Indeed, every science has its own language or train of thought in order to express its very nature, both in the research and the practical phases; every science is composed of concepts that can be learnt and explained only through its epistemological status.

The conformity between IT principles and its becoming objective of a scientific inquiry of different fields of knowledge, seems all very natural to us, as the scientific evolution based on effective dialogue between various methods of inquiry, has shown.

To give an answer to the original question raised, some fundamental aspects need to be clarified, such as which are the characteristics that scientists agree on regarding computational thinking (Corradini, 2017).

As a result of the epistemological analysis carried out, computational thinking is characterized by several features, such as routine, concept, procedure, skills, abilities, reasoning, etc., and it is impossible to fully and exhaustively articulate them. All these features are fundamental to computational thinking as each one of them come into play in all the activities in a way or another.

In this sense one can speak of the activation of mental processes, such as logical thinking, abstraction, imagination, but also operational methods and approaches, including analysis, evaluation, verification, simulations and pure practical elements of the experimental sphere. And last but not least, one can refer to transversal competencies, invoking the soft skills, creativity, collaboration, inaccuracy.

All these elements give rise to computational thinking, which represents and action in comorbidity and concurrent to various suggestive and necessary elements.

This principle is specified by Nardelli (2017), who extends Wing’s definition, describing computational thinking in this manner: “Computational thinking is a set of mental processes used to model a situation and to specify the ways in which an information processor can effectively operate within a particular situation to achieve one or more externally provided objectives”.

The scientific intensity of such a definition lies in some fundamental principles. First of all, computational thinking is a process, and therefore requires a series of elements to be carried out. Secondly, this process is fulfilled by an information processor that follows commands for a goal which is predetermined by external factors and is not self-generated. Finally, the action is coordinated by a component which designed and merges all the elements.

This latter aspect presents an opportunity to take in consideration the relationship between computational thinking and creative thinking. The connection between

thinking and creativity has given rise to several papers and articles, as it is a fundamental point to understand both better.

According to several experts, including Mitch Resnick (2020), computational thinking represents an authentic device for creativity; and it does so through the construction of representations of hypotheses and solutions to problems, through the enhancement of imagination by means of educational tools, through a network of information supporting the ideation and creation phase, through targeted actions for data analysis, and so on. Resnick himself states that “learning is lifelong, and to be enjoyable and effective, should be creative and playful”.

2. Computational thinking: a social and individual aspect for an active citizenship

In the document “National Guidelines and New Scenarios” developed in 2018 by the National Scientific Committee for National Guidelines for the Curriculum of Early Childhood and Primary Education, the importance of the development of computational thinking is emphasized as a guarantee for both individual and socio-democratic maturity.

Since 2015 the regulations issued, specifically Regulation 107/2015 and Legislative Decree No. 62/2017, aim to strengthen educational activities related to computational thinking.

This factor however cannot be confined only to Early Childhood and Primary schooling, albeit fundamental in providing a relevant logos to the society of today, but it should be extended to the entire time lapse that characterizes education from all perspectives: formal, informal and non-formal.

In pursuit of the adoption of the pedagogical guidelines in 2018, it has become more evident that providing computational thinking from the earliest stages of learning is essential, especially in a society that is constantly evolving and changing, where an active and proactive participation of citizens in the development of democracy and enhancement of culture, is in continuous expansion.

The National Guidelines state that computational thinking must be intended as a “mental process which allows one to solve problems of various nature by following specific methods and tools in order to plan a strategy. This creative and logic process, more or less consciously, is put in action in everyday life, to handle and solve problems” (2018).

In this way, children and adults alike acquire a method of thinking capable of efficient and effective analysis, programming and learning strategies, in search of creative solutions which are always tailored to a specific context. This analysis is not found only in the fragmentation of information, but as a fully-fledged educational action.

The nature of computational thinking technology confirms and encourages constant interaction between the variables involved in every evolutionary process (subject and machine, creators and consumers) and allows for a dialogue that keeps away the risks of isolation in employment and the individual's participation in their own life project.

Technologies are no longer seen as teaching methods rooted in the matrices of Watsonian behaviorism, but as a support and an integral part of a larger and more complex system: the thinking matrix.

Thus, here lies the certainty that computational thinking is not only mathematical thinking as in coding; neither is it linked exclusively to the teaching of STEM subjects, nor is it unquestionably tied to the use of machines or computer tools; it is rather a universal educational action suitable for every aspect of education.

The educational experience allows for and requires a programmed system to be created, or a problem to be solved through a series of actions or through a series of operations, as well as a planning phase, which can be accomplished optimally through computational thinking.

This however must be integrated and related to critical thinking: a metacognitive reflection and an initiative spirit inherent in the same planning of the implementation phases, and therefore not improvised or guided by chance. Critical thinking and computational thinking merge together to give rise to transversal skills which, according to Amicucci (2019), "allow understanding and guiding processes of change".

3. The relational network of computational thinking

Within the various schooling systems, computational thinking is associated to other speculative paradigms of forms of inquiry. For example, computational thinking is linked to:

- Logical-mathematical reasoning, in order to analyze a specific problem and find a solution;
- Engineering, where it shares the idea of evaluating the system in the real world;
- Science, in order to observe human intelligence, the subconscious and human behavior.

An overview of what has been stated and of the concentrated network of paradigmatic relationships that computational thinking binds in its progressive development, is given by Jeanette Wing, who published an article entitled "Computational Thinking" in March 2006.

In this paper Wing argues that "computational thinking" encompasses "skills and concepts that are useful to all, not just computer scientists" (Chiocciariello, 2013),

and thus establishes the need for a set of elements that characterize computational thinking: computational thinking goes beyond the ability to program a computer; computational thinking aims to resolve problems without reducing human thinking to function like a computer; computational thinking allows logical reasoning to interact with the construction of systems that operate in the real world; it is not about creating software, but about resolving problems, managing our daily lives, communicating, and interacting with other people; computational thinking is “for everyone and everywhere”, i.e., it is integrated into everyday contexts (Bruni, D’Onofrio, Nisdeo, 2016).

Computational thinking is an almost Aristotelian “logos”, capable on the one hand of merging a dense metacognitive network with other types of thinking and enhancing them; on the other hand, of scientific research and evolution.

The mission of education is to stimulate, deepen and define such a dialogue. Through pedagogical knowledge, education promotes the acquisition of specific skills capable of elaborating information and transforming it into actual actions for task execution and problem solving.

This has been highlighted in a recent study launched by the University of Genoa¹, which established the strong link between computational thinking and the responses given to problems.

Computational thinking employs its own language, its own way of reasoning, and its own vision of things and events.

Hence the awareness that computational thinking represents a skill to be taught to every child, from early childhood education up to tertiary education, and in the employment world too. We can state that it is truly a lifelong skill.

Marchignoli legitimizes the adoption of computational thinking within today’s educational landscape, characterizing it as a fundamental skill for the citizen of tomorrow (Marchignoli, 2016).

Conclusions

If we attempt to provide an answer – albeit never definitive – it would appear that computational thinking appears to possess all the characteristics of an integrated action, where various factors, elements and variables, come into play.

It is a true transversal skill, calling in play cognitive abilities and emotional aspects. This is basically the idea that Jeannette Wing (2006) wants to express when she asserts that computational thinking is the “fourth basic skill”, a skill on the par of reading, writing and numeracy. Thus, in the same way there is a need for a

¹ dutainment Formula. Smart O.C.A. Online Challenge Activity. In Italian. Available at <https://www.edutainmentformula.com/web-app/smart-oca/> (accessed June 2022).

computational literacy program, directed and oriented according to educational principles.

This belief also arises from what emerges within the “National Guidelines for the Curriculum”, issued in 2017, where there is a call for greater attention to the need, not only educational but also social, to acquire the basic languages belonging to modern society, among which computational language cannot be absent.

Shute (2017) defines computational actions as “the conceptual foundation required to solve problems effectively and efficiently (i.e., algorithmically, with or without the assistance of computers), with solutions that are reusable in different contexts”.

This definition highlights that the computational process is a true elaboration of thought, which can generate competences, intellectual modes, abilities and behaviors.

Essentially, while computational thinking has seen a growing interest from a pedagogical point of view, it still struggles to find its correct location in practical daily life and activities. This seems to be due to the lack of definition and its belonging to one particular label rather than another.

As far as we are concerned, it seems necessary to go beyond the speculative level and ask ourselves questions, to find spaces and time where computational thinking can express its educational potential even within school grounds.

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