Technology and society: Its contribution to the emergence of computational thinking

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ABSTRACT

Nowadays, technology has gained more space in our society and has increasingly been part of our routines. And when we talk about technology, it does not mean reducing it only to the use of computers and machines, because historically this term is broad and comprehensive. The modern and postmodern periods are important milestones in the history of the relationship between technology and society. The modern period, which extends from the sixteenth to the nineteenth century, was marked by the development of science and technology. The Industrial Revolution, for example, was a time of great technological advances, which had a profound impact on society. In the postmodern period, technology is becoming increasingly complex and fast-paced. This is driving significant changes in society, such as the globalization of the economy, the rise of popular culture, and the emergence of new social movements. One of the main contributions of technology to society is the emergence of computational thinking. Computational thinking is a way of thinking that is based on the principles of computing. It involves the ability to solve problems, think logically and creatively, and communicate ideas clearly and concisely Based on the understanding that modernity is born with the integration of science with technique, and that postmodernity questions this integration with broader conceptualizations and understandings, this article discusses the relationship between technology and society, focusing on the contribution of technology to the emergence of computational thinking. Technology is playing a key role in the development of computational thinking by providing people with tools, opportunities, and incentives to think computationally. Computational thinking is an essential skill for success in the modern world, and technology is helping people develop it.

Keywords: Technology, Society, Computational Thinking, Problem Solving, Logical Thinking, Creativity, Communication.

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INTRODUCTION

TECHNOLOGY IN MODERNITY AND POST-MODERNITY.

This ideological conception marks a modification of thought that until then was considered medieval because it was directed to the Christian faith, to a reflective thought aimed at valuing reason and experimentation.

The existing literature points out that modern philosophy has come to be known for several characteristics such as: the search to reach the truth, appreciation of reason, absolute knowledge, search for values; and, in these perspectives, they were organized into philosophical currents, such as the most expressive at the time, such as Empiricism and Rationalism.

According to Marques (2020, p.1)

> The first current gained strength from the ideals spread by philosophers René Descartes and Gottfried Wilhelm Leibniz. For rationalists, true knowledge was that obtained from rationality, and should eliminate everything that is learned from experiences. The second philosophical current, on the other hand, defended an idea contrary to rationalism, following the conception that practical experience was the key to the construction of knowledge. The more intense and rich this experience was, the greater and deeper this learning would be. The philosophers who pushed this current forward were Thomas Hobbes, John Locke, and David Hume.

The two modern conceptions just presented mark the discourse of the crisis of science in its theoretical nature and modified by productive technique. An example to cite is the physicist Galileo Galilei, who became known as the father of modern science for being the first to introduce experimentation into science.

As a result, modernity began to discuss not only the idea of experimentation, but also to think about the role of man in the domain of techniques. It is important to infer that Neto (2010) corroborates this statement when he asks that along with the idea of experimentation and technological intervention "the idea of scientific and technical conquest of all reality predominates, based on the mechanical and mathematical explanation of the Universe and the invention of machines, thanks to physical and chemical experiments". (NETO, 2010, p. 14)

However, this technological intervention can be understood as the way to recreate or produce something with nature in order to obtain improvements, which shows a strengthening between science and technique, and, according to Miranda (2002), technology would be a result of this union between science and technology.

According to Oliveira (2008) it is in the modern age that the term 'technique' comes to have the denomination of technology, the author also argues that events that occurred at that time such as (fall from feudalism, increase of trade, urbanization, alteration of the divine law by reason) "necessarily enabled the development of a new knowledge – modern science and technique or technology". (OLIVEIRA, 2008, p. 6)

Technology then becomes the center of discussions within modern society with a view to different understandings and associations, especially after the industrial revolution, being analyzed not only for its integrating power between science and technique, but also for its relations of use and power in the society known as industrial and later post-modern.

It is relevant within this delineation to understand that postmodern philosophy is a philosophical movement that was born in the middle of the 20th century. However, this movement appeared in the form of criticism of philosophical ideas about modernity with regard to concepts such as culture, language, history and identity, very present during the eighteenth century with the Enlightenment.

Within this scenario, **Jean François Lyotard is presented** as one of the greatest philosophers to conceptualize postmodernity, so that his ideas continue to reverberate through the revolution of the impact of technology between knowledge and the computerized world. In his work "The Postmodern Condition" it is observed that the author makes a reflection and analysis on science, knowledge and technology in capitalist societies.

His study has as its central hypothesis the understanding that "knowledge changes status at the same time that societies enter the so-called post-industrial age and cultures enter the so-called post-modern age". (LYOTARD, 2009, p. 3). This statement leads to reflections that are as current as those posed by the author, because in a larger context it would be to ask the question: What is the place of knowledge within developed societies?

However, what Lyotard wanted to express in his study would be a modification of science in its nature caused by technological repercussions, based on the assumption that "Scientific knowledge is a kind of discourse". (LYOTARD, 2009, p. 3)

The author also adds that:

> Now, it can be said that for forty years the so-called avant-garde sciences and techniques have dealt with language: phonology and linguistic theories, the problems of communication and cybernetics, modern mathematics and informatics, computers and their languages, the problems of translating languages and the search for compatibilities between languages, machines, the problems of memorization and databases, telematics and the installation of "intelligent" terminals, the paradoxology: "here are some evident proofs, and the list is not exhaustive. (LYOTARD, 2009, p. 3)

What the author brings with this question would be a reflection that knowledge loses its sense of formation and, as cited by Telles (2017), knowledge changes configuration because there are producers and consumers of knowledge, causing knowledge to be produced to be sold.

However, this view brought by Lyotard refers precisely to the fact that it is necessary to understand how much technological transformations impact the means of production and the way knowledge is distributed. Therefore, in his theoretical path, the author adds that scientific knowledge presents conflicts of legitimacy between knowledge and power.

Another relevant issue raised by Lyotard is his statement that "the postmodern scenario is essentially cybernetic, computerized and informational." (LYOTARD, 1998, p. 7)

With this statement, the author brings a perspective that efforts should be made to computerize society, whether these efforts are technological, scientific or political. (NESPOLI, 2004).

From this perspective, it would be necessary to understand the understanding of what the computerized society would necessarily be, starting from the understanding that the computerized society emerged as a delineation of a new society that was later called the information society, as follows.

THE INFORMATION SOCIETY AND THE KNOWLEDGE SOCIETY

Studies indicate that the term information society first emerged as a concept with the economist Fritz Machlup, when he published his book in 1962 entitled The Production and Distribution of Knowledge. However, as Coutinho and Lisboa (2011) infer "the development of the concept is due to Peter Drucker who, in 1966, in the bestseller The Age of Discontinuity, speaks for the first time of a post-industrial society in which the power of the economy would have evolved from agriculture to industry". *(*COUTINHO; LISBON, 2011, p. 6)

In addition, history points out that the information society was born in the middle of the twentieth century, marking a time when technology made great advances, and this view refers to a reflection that the information society would be a successor to the industrial society. In this way, the information society begins to take shape in a conjuncture of technological development.

It is in this context that Manuel Castells Oliván, a Spanish sociologist and university professor, began to talk about the transformation of an industrial society into an informational society, a movement that began in the 1970s. The author sought to analyze the information society or information age from the perspective of understanding how society is reconfigured from information and communication technologies (ICTs), and what is the impact caused by technological advancement.

Castells focuses his study on this new configuration known as the Information Age, or Digital Age, where in this new delineation of society, the movement of action exerted is in relation to the technologies that evolve so that the individual acts on information. Thus, the author writes one of his most important researches called "The Information Age", which was published in trilogy format between 1996 and 1998.

In the first volume "The Network Society", Castells starts to bring a concept of informational capitalism, because according to him capitalism has to reinvent itself to get out of the structural crisis. This would only be possible through technological advancement and productive restructuring.

With this, he argues that information technologies would be the paradigm to restructure the mode of production. However, for Castells, it is useful to highlight the paradigms of information technology as central aspects so that they can serve as a kind of guide for future paths of social transformation. Namely: "technologies to act on information"; "the penetrability of the effects of new technologies"; and "the logic of networks" (CASTELLS 1999, p. 108)

In the second volume "The Power of Identity". The author places as a central key to the edition the distinction of three forms of identities, namely: legitimizing identity, identity of resistance and identity of project.

And, finally, in the third volume "End of the Millennium" the author conducts an important study on the economic and political transformations that took place in the extinct Soviet Union, and brings a description of its relationship with the information system.

Despite discussing the important role of technology in society, the author ponders that it is not only technology that defines society, but also economic, cultural, and political factors that constitute the network society.

Corroborating, Gouveia (2004) argues that technologies alone would not have the power to transform society alone, because it must be understood that they are used by people in their multiple spaces and contexts, both economic, political and social. As the author infers:

> The Information Society is based on information and communication technologies that involve the acquisition, storage, processing and distribution of information by electronic means, such as radio, television, telephone and computers, among others (GOUVEIA, 2004, p. 1).

Corroborating, Oliveira and Bazi (2008) reflect that in the historicity of the Information Society, there are divergences in its historical context with that of other periods, as is the case of the history of post-modern society, information technology and the knowledge society.

When it comes to the Knowledge society, this concept appeared in the 1990s. Núñez (2022) argues that, soon after telecommunications and information technology experienced their peak in the 1970s, society needed new circumstances for the processing of information. Also according to the author, it was in this context that in the 90s the debates intensified, giving rise to the term knowledge society, which would be an option to the term information society.

However, Leite[2] complements by stating that it was from 1995 that the term knowledge society was introduced "on the agenda of meetings of the European Community and the Organization for Economic Cooperation and Development, which brings together the thirty most developed countries on Earth." Thus, the term was adopted by the World Bank and the U.S. Government.

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Burch (2005, p.3) emphasizes that:

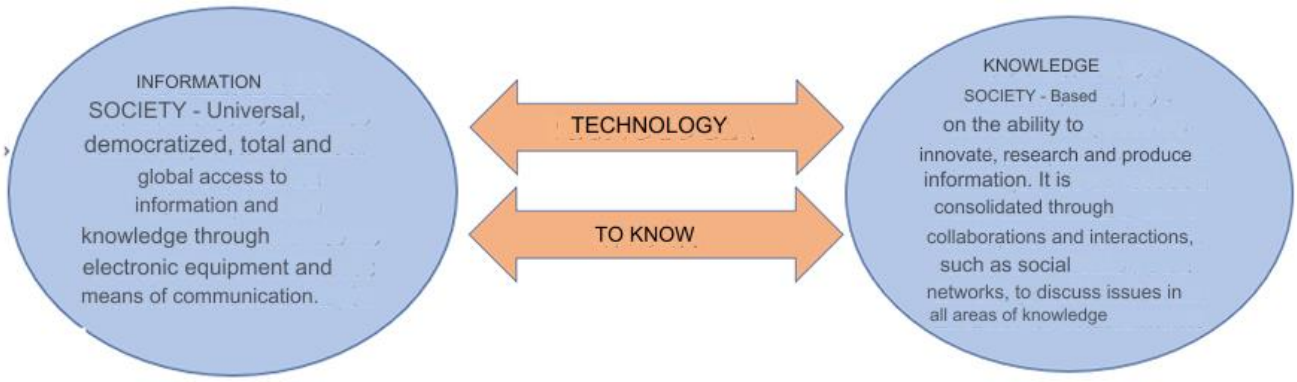
> [...] UNESCO, in particular, has adopted the term "knowledge society" or its variant "knowledge societies" within its institutional policies. He developed a reflection on the subject that seeks to incorporate a more integral conception, not linked only to the economic dimension.

Burch cites that UNESCO Deputy Director-General Abdul Waheed Khan argues that using the concept of the knowledge society is better than that of the information society because it is a more coherent way of expressing the complexities and changes that are taking place.

In addition, the author infers that both companies have their relevance. The Information Society, due to its contribution to analysis, technology exerts a fundamental influence on the system of society, standing out as a driver of economic progress. And the Knowledge Society has its relevance because it guides policies and actions, and "technology is the support that triggered an acceleration of this process; but it is not a neutral factor, nor is its course inexorable, since technological development itself is guided by games of interests". (BURCH, 2005, p. 5)

However, these definitions of concepts even contribute to a single definition called the Information and Knowledge Society, which has also not been widely accepted by some scholars. After a careful study of the definitions of these companies, the general characteristics intermediated by two links are presented in a simpler logic of understanding, as shown in figure 1 below

Figure 1. Definitions and links between the terms Information Society and Knowledge Society.



Source: prepared by the authors.

What is observed is that these two concepts are often confused or even in some contexts are used in confusing or random ways, as if both had the same meaning. However, that is why so many discussions arose in order to align and define each one, bringing their distinctions. (NETO; JUNIOR; VALENTINE; 2013)

However, there are important discussions about these two concepts. An example would be that of the author Newton Duarte, who makes a critique of the knowledge society, because according

to the author this society "is, by itself, an illusion that fulfills a certain ideological function in contemporary capitalist society". (DUARTE, 2008, p. 10)

Regarding the links between Technology and Knowledge, they permeate the two spheres of societies discussed, presenting the same relevance with different roles, where Technology processes and brings development and Knowledge adds and gives value, and both have their interfaces in the economic, social, political and educational spheres.

Considering here only the educational sphere, we have, concomitant with these configurations of societies, the effect of these movements on teaching-learning, where in the Information Society what exists is the intensive use of Information and Communication Technologies (ICTs), not only in the sense of bringing innovation to teaching, but also with the objective of relating science, technology and education.

In the knowledge society, ICTs continued to be used, but in the 80's Papert through the language Logo[3] introduces computing in basic education and with this emerges what would be called computational thinking. (BRACKMANN, 2017 p. 24)

COMPUTATIONAL THINKING – EMERGENCE, CONCEPT AND PILLARS.

The term computational thinking is increasingly used today, according to Jeanette Wing (2006) it consists of a group of skills and attitudes that everyone, not only computer scientists, were interested in learning and using. This statement by the author is due to the fact that it is an emerging term and that it was used for the first time by Seymour Papert in 1980.

Vieira (2018, p.27) cites that although Computational thinking is a term used by Wing in 2006, previous authors such as Alan Perlis in the 60s and Papert in the 80s already explored this idea in their works, however the enunciation computational thinking became evident only when she published an article in Communications of the ACM, a journal of the Association for Computing Machinery[4].

In this article, the author argues that computational thinking is an essential skill for everyone, not only for computer scientists, with this the author brings the prominence of the discussion of the integration of computational thinking with other areas of knowledge and other disciplines.

According to Wing , computational thinking "involves solving problems, designing systems, and understanding human behavior by extracting fundamental concepts from computer science." (WING, 2006, p. 33). The reflections brought by the author refer to an understanding in the sense of a definition of what computational thinking would be and was the basis for discussion for other

[3] A programming language designed to be a learning tool.
[4] Association for Computing Machinery – created in 1947 and is the first scientific and educational society designated to computing.

scholars in the area to focus on the understanding and use of the term computational thinking. However, according to RAABE; ZORZO; BLIKSTEIN (2020) the term does not have a closed and defined construction, given that there are numerous disparities in definitions and understandings of the term. Let's look at some concepts:

"It is the process of recognizing aspects of computing in a world around us and applying tools and techniques from Computer Science to understand and argue about natural and artificial systems and processes." (FURBER, 2012).

"Computational Thinking is a methodology that is acquired by learning concepts from Computer Science and, therefore, is not characterized as a discipline by itself. However, as a methodology, it can and should be used, in an interdisciplinary way, in any other discipline". (VICARI; MOREIRA; MENEZES, 2018, p. 25)

"Computational Thinking refers to the ability to systematize, represent, analyze, and solve problems." (SBC, 2017, p. 3)

"Computational thinking is the process of thought involved in formulating a problem and expressing its solution(s) in such a way that a computer – human or machine – can effectively accomplish." (WING, 2017, p. 8)

For Brackmann (2017) there is another question when defining the term computational thinking that would be the limit between Computing and Computational Thinking or what interaction Computational Thinking would have with Computing, for this author the boundary between them was not clearly established.

The outlines, studies and discussions deal not only with the understanding of the term and its scope, but also break down deeper barriers between its conceptions and characteristics associated with computer science. And it is in this sense that the four pillars of computational thinking emerge with the purpose of guiding problem solving. They are:

1. **Decomposition**: it consists of the ability to discover a complex problem and break it down into small parts that are easier to conduct and manage.
2. **Pattern recognition**: Recognize similar problems or similarity to situations already presented previously using previous experience to solve them.
3. **Abstraction**: focusing on the most relevant data without privileging the details, and thus defined, the non-relevant ones are discarded, allowing the solution to be applicable to other problems
4. **Algorithmic thinking:** consists of the ability to create instructions (steps) or solutions with the purpose of solving the problem.

Based on these four pillars, it is easy to understand that computational thinking is present in our daily lives in the most diverse forms and situations of everyday life and, according to Noleto (2021), using certain computational thinking skills can generate more success in solving problems.

Wing (2007) emphasizes that computational thinking will be an essential skill to be used by everyone in the world in the mid-21st century, and computational thinking "enables what a human being cannot do alone to: solve problems; design systems; understand the power and limits of human and machine intelligence" (WING, 2007, p. 3)

The author is a visionary in this sense, because computing in basic computing is a reality that is increasingly present in all curricula in the world. Computational thinking has brought into teaching a new methodology that uses different skills to teach and learn by associating the most diverse areas of knowledge.

FINAL CONSIDERATIONS

Computational thinking is consolidated as an essential skill for the information and knowledge society. This is due to the fact that technology is transforming the way people work, learn, and communicate

It is noteworthy that in the information society, people need to be able to solve problems in a creative and innovative way. This requires computational thinking, which allows people to analyze problems, identify solutions, and implement solutions.

It is clear that in the knowledge society, people need to be able to learn quickly and effectively. This requires computational thinking, which allows people to understand complex concepts and apply the knowledge in different situations.

It is evident that discussions about information technology and the knowledge society contributed to the emergence of computational thinking by highlighting the need for digital skills and complex problem solving in the information age.

It is concluded that in the information and knowledge society, people need to be able to communicate clearly and concisely. This requires computational thinking, which allows people to organize ideas and convey them effectively.

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