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Ensayos

Complejidad y método científico

Complexity and Scientific Method

Complexidade e método científico

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> La enorme masa de saber cuantificable y utilizable no es más que veneno si se le priva de la fuerza liberadora de la reflexión.
>
> JÜRGEN HABERMAS Y THEODOR ADORNO

Resumen

A menudo nos preguntamos, mientras observamos fenómenos naturales: ¿cómo funciona la ciencia? ¿puede explicarlo todo? La complejidad se presenta como un paradigma que puede ayudar a llenar los vacíos que ha dejado la ciencia positivista. Porque el sentido holístico de su carácter epistemológico podría ayudarnos a comprender mejor tanto el mundo natural como el social. Una comprensión que nos conduzca a la acción, pues los tiempos complejos actuales demandan la intervención oportuna del ser humano en los problemas que, en su mayoría, él mismo ha generado.

Palabras clave: ciencia, complejidad, método científico, racionalismo.

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Abstract

We often ask ourselves while observing natural phenomena: how does science work? Can she explain it all? For this reason, complexity is coming as a paradigm that can help fill in the gaps that positivist science has left. For the holistic sense of its epistemological character could help us better understand both the natural world and the social world. An understanding that leads us to action, since today's complex times demand the timely intervention of human beings in the problems that most of them have generated.

Keywords: science, complexity, scientific method, rationalism.

Resumo

Muitas vezes nos perguntamos, ao observar fenômenos naturais: como funciona a ciência? pode explicar tudo? A complexidade é apresentada como um paradigma que pode ajudar a preencher as lacunas deixadas pela ciência positivista. Porque o sentido holístico de seu caráter epistemológico poderia nos ajudar a compreender melhor tanto o mundo natural quanto o social. Uma compreensão que nos leva à ação, pois os tempos complexos de hoje exigem a intervenção oportuna do ser humano nos problemas que, em sua maioria, eles mesmos geraram.

Palavras-chave: ciência, complexidade, método científico, racionalismo.

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Introduction

Like the waters that inspired Heraclitus' notion of change, science, the scientific method and thought have also experienced historical processes of conceptual reconstruction that have helped shape the world we live in today and have provided us with a methodological baggage to face the problems of the XXI century society.

In this sense, classical modernity was the philosophical catapult that guided humanity towards the incipient path of epistemological reflection. Undoubtedly, René Descartes (1596-1650) was one of the main characters in promoting this advance, since his rationalism allowed him to lay the theoretical foundations of knowledge. The French philosopher inherited us, through his "methodical doubt", a method of thinking that recognized the cogito as that finite and thinking substance that gives rise to everything that exists and that

recognized reason as the fundamental element that distinguishes the human being from any other existing race.

In addition to this, René Descartes also invited us, on the metaphysical plane, to develop a rational subjectivism in which it was possible to think about the knowledge of the object through the subject, that is, to totally forget about the imagination and the Platonic world of ideas to land on what is palpable, what can be observed and, to a certain extent, "measured". With this contribution, René Descartes founded a conception of the world based on mechanism as a form of mathematical rationality that was concretized from the four rules of his method discourse: evidence, analysis, deduction and verification. The first rule states that "only what is perceived is true". Analysis is the reduction of the complex to the simplest to review it in parts. Deduction is the formation of hypotheses from what is being investigated. Finally, the check checks whether each of the above rules are met.

René Descartes gave philosophy the formality it needed to establish itself as "a possible path to the truth", as a science in the full extension of the word, which separates doxa from episteme, opinion from reason; and thus be able to evolve from the medieval postulates that were more concerned with the static object than with the thinking subject.

In short, mechanism (conceiving of man as a machine) was one of the strongest links in the chain of the evolution of thought. Its value and strength are undeniable, since it laid the foundations for modern thought and served as a pretext for the development of the first scientific revolutions in moments of civilizational crisis.

Developing

In the same vein as the introduction, we can mention Isaac Newton (1643-1727) and Emannuel Kant (1724-1804) as precursors of the first scientific revolutions. The former formulated some mechanistic postulates that governed the philosophy of the Enlightenment in the second half of the 18th century. The second, for his part, developed a theory of knowledge, aligned with his own rationalist and empiricist postulates, which laid the foundations and marked the limits of what he conceived as human reason, a philosophical paradox, since in his Critique of reason Pura affirmed that "the world does not have a beginning of time nor an extreme limit in space" (Carvajal, 1993, p. 3). However, as heir to Descartes and the scientific method, Immanuel Kant also built his law of causality, with which he intended to bring order to all kinds of knowledge built from the natural and the

social. This law, without a doubt, continues to be one of the strongest postulates of classical positivist science.

In addition to the aforementioned scientific outbursts, Charles Darwin (1809-1882), in the 19th century, made one of the greatest contributions in the history of mankind. Based on the hypothetico-deductive method —previously formulated by Newton—, he released convincing research on the processes of adaptation of living organisms to the environment and natural selection. Thus, he founded evolutionism as a scientific discipline that to this day gives us a structured view of the origin of species and human evolution. Said evolutionism had an impact on both the philosophy and psychology of that time, because it radically changed the divine conception of the creation of the natural and social world, in addition to planting in the human being the possibility of being the only one responsible for his destiny.

Shortly after Charles Darwin, theorists such as James Clerk Maxwell (1873), Heinrich Hertz (1887), and HA Lorentz (1892) broke out in formulating the principles of electromagnetism in the second half of the 19th century, although these principles did not entirely break with the Newtonian postulates. Later, Ernst March (1838-1916) and William Ostwald (1853-1932) published views on different aspects of science. While one worked on the phenomenology of science based on positivism, the other tried to free it from the exclusivity that physics had at the time. However, this last task could not be fully achieved, since one of the most outstanding scientists of all time would appear on the scene: Albert Einstein. (1879-1955).

Einstein, known for his famous theory of relativity, managed to reformulate the concepts of space and time that Isaac Newton had previously raised in his Principia. Einstein considered that each body has its own spatial time, that is, that what we know as absolute time does not exist. In this way he made his triumphal entry into quantum mechanics, whose development in the 20th century broke a large number of already established deterministic paradigms and caused one of the greatest scientific revolutions in the history of mankind.

Under the scientific scheme of quantum mechanics, the contributions of Ludwing Boltzmann (1899), Max Planck (1918), Niels Bohr (1922) and Werner Heinsenberg (1927) came to light, among others, who, housed in the notion of general relativity changed the conceptual framework of the deterministic century: people began to talk about macrocosms instead of microcosms, of uncertainties instead of certainties, of a dynamic and expanding universe contrary to the Newtonian idea of a finite and static universe. But not only that, but

also the concept of chance was integrated into the language of science as a need to articulate nature with complex processes.

Even more, following this same logic, Tomas Kuhn (1922-1996) in 1962 tried to unravel the postulates of "mature science" by publishing his book The structure of scientific revolutions, where he conceptualized normal science as a "research based on in one or more past scientific achievements recognized by some scientific community for a certain time, as a foundation for its later practice" (Kuhn, 1971, p. 33). From this concept also emerges that of paradigm as a set of common rules and norms to carry out scientific practice (Kuhn, 1971). That is to say, a paradigm allows to provide models of scientific research practices and possesses by itself a vision of the world, with the values and the conceptual framework that it brings together; and it is, according to Tomas Kuhn, the great discoveries that originate scientific revolutions (the moment in which one theory prevails over another).

But what causes paradigms to appear and these types of revolutions in scientific knowledge to take place are the crises in science, they are those stages of profound professional insecurity that require a precise response from the scientific community in turn, since the scientist, As a good science professional, as an entity of knowledge, you must have the necessary competence to react to the tensions of the disordered world in which you live. Crises allow the profound reconstruction of established paradigms or, in this case, if the occasion warrants it, welcome a new one.

Thus, by unraveling the conceptual plot of science, the American physicist and philosopher focused on what the function of scientific work should be. Indeed, he emphasized that the fundamental task of science is to develop the use of new procedures for the study and resolution of scientific "enigmas", solvable enigmas that could test the creativity and ingenuity of those who do the research. research, because doing science invites us to look for different ways of studying the same problem in order to obtain better and better results.

Over time, scientific revolutions have transformed the world views of the societies in turn. For this reason, recognizing them as fundamental elements for the development of humanity helps us to live uncertainties with awareness and, at the same time, favors the epistemological evolution of each planetary era. In this sense, the ideas and postulates of Edgar Morin (1984) fit perfectly to try to give a reasoned explanation about science, the scientific method and the emergence of paradigms.

Edgar Morin agrees with Tomas Kuhn about the elucidating function of science. For Morin, the main reason for the existence of science is the resolution of enigmas and the

dissipation of mysteries. However, he is careful to conceive of science as an idea of progress, since, according to the thinker himself, a science without conscience is ambivalent. Although knowledge gives us development, it can also become a threat of self-destruction (atomic bomb) if not used properly.

Edgar Morin bases his postulates on the Pascalian idea of a holistic science, in the sense of taking into account the relationships between the whole and the parts closely. According to this contemporary philosopher, we have spent a lot of time dealing with disjunctive thinking that separates nature from culture and object from subject; This is not a healthy situation, since the important thing is to respect the autonomy of these agents and establish the necessary relationships to transform our cognitive structures in favor of holistic knowledge and comprehensive development of science, where nothing is superfluous and each is covered. one of the existing dimensions. It should be noted that this conception was also influenced by Bertalanffy's systems theory.

In the same tenor, Edgar Morin redefines the idea of cumulative and linear "progress" of classical science to think of a reflexive progress, with self-criticism and based on uncertainty, since he considered that "too much information obscures knowledge", which which means —extrapolating the idea to the real world— that quality of life does not automatically improve because of scientific and technological advances . For this reason, real progress recognizes ignorance, chance, order and disorder, that is, complexity as a fundamental element for the analysis, reflection and transformation of reality.

Complexity, according to Edgar Morin, is a way of "thinking from order and disorder despite the irrational and the inconceivable" (2008, p.15), it is a mechanism of self-generating processes of scientific knowledge. It is the confused, the tangled, what cannot be simplified within reality, that which acts under a transdisciplinary and totalizing logic. In concrete terms, the complex (Morin, 1988):

- Associates with the object and the environment.
- Binds the object to its observer.
- Recognizes the object as a system.
- Disintegrate the simple.
- Confront the contradiction.

In this sense, complexity stands as a method that takes into account what classical science had left aside, ignored or discriminated against, since it conceives progress through

the recognition and denunciation of error, falsehood and deception. Could we then say that what Edgar Morin raised is a paradigm? Yes, the paradigm of complexity.

Later, Edgar Morin describes the generative and strategic principles of his method. It should be noted that, in Morin's words, the method is precisely that "generative tool of strategies" (Morin, 2002) and a strategy is art itself, with its multiple doses of reflexivity. The seven principles are briefly described below:

- *Systemic or organizational principle: it refers to the ideas of Blaise Pascal (1623-1662) and Ludwig von Bertalanffy (1901-1972): study the whole from the parts and the parts from the whole, without forgetting that they are related tightly.*
- *Hologrammatic principle: refers to understanding the individual as a hologram of society, as a small sample of it.*
- *Principle of retroactivity: refers to the idealization of a loop that breaks with the linear causality of classical science and constantly rebuilds itself.*
- *Principle of recursion: this is one of the fundamental principles and emphasizes a dynamic of self-production between the subject and the object, where both are dependent on each other.*
- *Principle of autonomy/dependence: it is a principle that seeks self-organization to develop autonomy from the environment where the subject develops.*
- *Dialogical principle: the different logics or ways of thinking can complement each other and associate in a complex way.*
- *Principle of reintroduction of the knower in all knowledge: this last principle seeks to revive the role of the subject within the investigation, since it is he himself who constructs the reality under study.*

Taken together, all these principles represent some elements of social maieutics: there is always the task of creating new knowledge for the benefit of society.

Now, psychosociological Socratism refers us to the constant interrogation of problems. This means that the research subject within the paradigm of complexity is not closed to single-causal events, but rather investigates the multidimensional under the premise that "to think is to build an architecture of ideas, and not to have a fixed idea" (Morin, 2002, p.33).

In this regard, one of the most outstanding elements within the paradigm of complexity, and which makes it different from other scientific paradigms, is recursion,

because it allows the interrelation of different discourses and systems from science, technology and society. That is: the paradigm of complexity is not only dialogical, but also recursive, and not only conforms to the interpretation of man, nature and society, but also seeks in every way the transformation of these, seeing them in their entirety. and from multiple dimensions.

In addition to the above, we can also mention that recursion is at the same time the product and producer of causes and effects, since it is a process that produces itself from the union of the unique and the multiple. With this idea, the paradigm of complexity opposes the simplicity of common deterministic science, moves away from reductionist positivism and focuses knowledge towards transdisciplinarity as a new way of thinking about reality. This struggle between the simple and the complex is what many have misunderstood as a scientific dichotomy, however, as happens in a paradigm shift, the new builds on the old, builds on it and never completely ignores it.

However, to enter the world of research from complexity, it is not only necessary to understand the need for a polyglot science, nor is it enough to conceive society as a complex community, but it is of great vitality to have research tools that favor concrete data. about the studied problem. Some of those that Edgar Morin (1984a, 1984b) suggests are:

- *Phenomenographic observation: it is a variant of systematic observation; it is a personal diary with panoramic overtones, which does not focus only on certain emerging patterns, but also covers the totality possible to record. For this, data that could be considered insignificant are not discarded, since the complexity takes into account the universe in its entirety, without discrimination of any kind.*
- *Interview: it is a technique and, at the same time, a research instrument that aims to delve into the essential needs of the interviewees to review all the subjects from multiple perspectives. These interviews seek that "the word of the interviewee is freed from inhibitions and discomfort and becomes communication" (Morin, 1984b, p.5)*
- *Group and praxis: it is the action from Marxism in reality and the action of social groups to provoke a situation of improvement; on various occasions, it requires a sense of rational spontaneity, that is, acting in the face of an unforeseen event with the experiential baggage and the theory that we have learned over the years.*

Although the aforementioned research tools can be identified within the field of action research, it is necessary to recognize that what is important is the change of focus, since

within the paradigm of complexity what is investigated is dynamic, totalizing and eminently multidimensional. Therefore, the aim is not to detect only a few emerging patterns for the study, but rather to analyze and reflect on the agents in a complex way, with the relationships they have with each other. In addition, to distinguish the rational nature of these instruments, it is of great importance to clarify what is meant by reason, rationality and rationalization, because although they have a certain semantic relationship, they do not mean the same thing within the complexity that Edgar Morin raises. Reason is the "will to have a coherent vision of phenomena, things and the universe, with an indisputably logical aspect" (Morin, 1988, p.7). Rationality, for its part, "is the game, the incessant dialogue between our spirit, which creates the logical structures, which applies them to the world and which dialogues with the real world" (Morin, 1988, p.7). Finally, rationalization "consists of wanting to enclose reality within a coherent system, and that everything that contradicts that coherent system be discarded, forgotten, set aside as illusion or appearance" (Morin, 1988, p.7). For this reason, the work of complexity oscillates between the first and the second term.

So, once we know the holistic universe of the paradigm of complexity and the small or large differences with the classical scientific method, we can ask ourselves: is the scientific method an obsolete procedure? We dare say no. Well, there are still disciplines that are based on it and obtain satisfactory results. However, the particularity and the temporal-spatial context that we currently live in demand us different alternatives to face the scientific challenges of the present and the future. To be more specific, it can be stated that in the case of the so-called "exact sciences" —excepting perhaps physics— there has been no need to search for new research methods, since their nature is consistent with the positivist nature of the field. classical scientific method. Something different from what happens with the social sciences, where the multicausal nature in which these disciplines are developed does not agree with the reductionist procedures of positivism and therefore require different ways to analyze reality, far from the classical scientific method.

Complexity, then, is not the dichotomous part of the scientific method, but it is an important counterweight to that approach because the incorporation or discrimination of randomness in both directions is itself its greatest point of discrepancy. The classical scientific method is oriented more towards what is measurable, quantifiable, perceptible and concrete; complexity prefers that point of doubt, subjectivity and uncertainty in natural and social processes.

Positivist science does not conceive of vanishing points or variables without control. Complexity, on the other hand, contemplates everything that can influence the course of an investigation or scientific problem, subjects, objects and the relationship between them (the dialogical); but above all, it takes random into account as a notion of great importance in today's natural and social processes, since the occurrence of some natural phenomenon out of season (rainy in winter, cold in summer) is currently unpredictable in everyday life. , for example), the same happens with human beings (car bombs, terrorist attacks, etc.). In other words, we have had to live in a time where order can be disorder and vice versa. For this reason, we also have to be part of that generation that can intervene from Freirian awareness and seek answers to the question of what we can do today so that tomorrow we can do what we cannot do today.

Now, if we conceive the existence of complex thought from the paradigm of complexity, it is also worth mentioning that simplification is based on a type of simple thought. Therefore, it is important to establish the most relevant differences between the two.

In the first place, simple thinking uses a principle of universality with which it seeks to standardize the results of an investigation in different contexts. While complex thought takes into account the conditions of each context for the explanation of its reality, without any interest in standardization.

Another important aspect that differentiates these types of thinking has to do with causality and temporality. Complex thought contemplates the historical evolution of thought, its interference in the future and the eternal dialogue with the past, that is, if it is necessary to return to some idea or technique from the past to solve a present problem, complex thought accepts it and supports it, that is the complex causality. However, in simple thought it is inconceivable to return to the ideas of the past, since it would undermine the linear causality that it defends.

The issue of order and disorder also causes a rupture between both thoughts, because as long as simple thought continues to suffer from a certain type of obsessive-compulsive disorder in reference to the elements of the universe, it will continue to miss the opportunity to learn from the epistemological richness that exists within the universe. disorder. On the contrary, a complex thought sees randomness as an opportunity for order and disorder to meet, where nothing can be so perfect and impeccable, since the universe itself and the human being as a whole are complex notions that are reconstructed each other day by day.

Finally, the disjunction between the object and the subject also implies the distinction of simple from complex thought. The positivist nature of the former is based on objective thinking, which indicates that only the actions of the subject can affect the object, since the latter is a static component. For its part, complex thought promotes taking into account the object and the subject as elements that complement each other in the interaction, that is, both the subject can transform the object and the object the subject. Something very much arises in Freire's conception (1965) of educator-learner and learner-educator, which for traditional science would be inconceivable at the moment.

For this reason, it can be thought that complexity has been the paradigm in response to the current crisis of civilization. Thus, the scientific revolution of which we are already a part invites us to have an open mind and understand that new times also require new methods, techniques and strategies for the study, analysis and reflection on planetary problems. Complexity should become, then, that theoretical-practical framework that allows us to navigate with balance between the calm waters of the scientific method and the risky gales of ignorance. Complexity is chance, uncertainty, recursion and retroactivity; it is one of the strongest epistemological links in the evolution of contemporary thought.

That is, we understand that the principles of uncertainty and the influence of chance in the configuration of current societies demand theoretical approaches that take them into account. For such a case, the paradigm of complexity is one of the best options from which to intervene.

Thinking and acting from the complexity will demand, yes, a series of tasks according to the holistic nature of the approach. However, depending on the improvement of the living conditions of the agents involved in the societies in which we operate, it will undoubtedly be worth facing this complex challenge.

Conclusions

As a result of the topics reviewed in this essay, we can conclude that there are other ways of seeing reality different from the one that our initial training has shown us. Indeed, both in basic education and in upper secondary and higher education, classical science has been the theoretical support of study plans and programs. Although that does not mean that one cannot reflect on their own training, especially taking into account that knowledge is constantly changing and that as subjects we must adapt to these changes. For this reason, in

the times of uncertainty of this 21st century, it is convenient to rethink the methodologies, techniques and research approaches, because classical science is not the only possible way to explain natural and social phenomena.

In addition to the above, it is necessary to venture from transdisciplinary approaches, where the reconciliation of science and philosophy is sought, where real emancipation is promoted and complex processes of reflection and action are contemplated. It is necessary, then, to start living in complexity, because the world is complex and we are all complex.

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