REVIEW AND PROVIDE MODELS AS HEURISTIC PROCEDURES TO THE DEVELOPMENT OF SYSTEMS IN HUMAN GEOGRAPHY

Mofareh. Mojtaba, Majnoony Tootakhane. Ali

Department of Art & Architecture, University of Bonab, Bonab, Iran a.majnoony@gmail.com
Department of Art & Architecture, University of Bonab, Bonab, Iran m.mofareh@bonabu.ac.ir

ABSTRACT

This article tries to deal with the model as a heuristic procedure, understanding heuristics as a particular technique to the formulation and resolution of problems, which is fundamental in the process of acquiring scientific knowledge, according to Lakatos. Are addresses the issues of the heuristics within a scientific research program, as the positive and negative heuristic. Then we present the model concept and how it can be used as heuristics to solve problems. Finally, the models are understood as heuristics within systems. In the conclusion it is discussed the advantages the heuristics of the models can bring to the use of the systems in Geography, parting from applied aspects until the help in the process of creation of hypotheses.

Key-words: *Models, Heuristic, Systems, Geographic Systems, Human Geography.*

INTRODUCTION

Models have been used as simplification of the reality for thousands of years present in a special type of interpretation human being, based in the reasoning, that will inspire great philosophical framework as the rationalism. Of classical Greek philosophers we should the paternity of several buildings designed in the rational form of mental models such as the atomic model of Democritus (400 BC), and models of celestial mechanics, such as Hipparchus (around 150 BC) and Ptolemy (around 150 AD), also, remarkable for his contributions to the geography and layout of the coordinate system for locating points on Earth's surface.

What is special in the 20th century is the refinement which was made possible by the advancement of Mathematics, which enabled the construction of more trustworthy models and the advancement in the Computer Technologies, which allowed not only to calculate huge volumes of data and thus to generate models which could include hundreds of variables, but also support the spatial representation of phenomena and their interactions with geographical information systems which could be able to simulate diligently the entirety of the globe. The possibility of construction of such models is basic to the development of the spatial analysis, which contributes to Geography very much. Understand and visualize the world in the form of systems requires the construction of the variables of these systems, and therefore, advances the need for modeling.

Methodologically, this article tries to deal with the model as a heuristic procedure, understanding heuristics as a particular technique to the formulation and resolution of problems, which is fundamental in the process of acquiring scientific knowledge, according to Lakatos (1976; 1978). Thus, modeling supports the understanding of systems as a structuring element of knowledge.

In the conclusion it is discussed the advantages the heuristics of the models can bring to the use of the systems in Geography, parting from applied aspects until the help in the process of creation of hypotheses.

STRUCTURE OF SCIENTIFIC RESEARCH PROGRAM AND FUNCTION OF THE HEURISTIC

The etymological origin of the word heuristic comes from the Greek *heuriskein* (Εὑρίσκω - "to discover") in the same trunk that gave to origin to the term Eureka. The heuristic can be understood as a set of rules and procedures that lead to alternatives to solving problems, with satisfactory solutions, but not always using the best reply. . In accordance with French (32) "*heuristics is now understood as the study of methods and approaches that are used in discovering and solving problems. A heuristic is somewhere between the formality of logic and clear glimpse of the seemingly chaotic and irrational inspiration*". In philosophy, the adjective "heuristic" (or the designation "heuristic device") is used when an entity X exists to enable understanding of, or knowledge concerning, some other entity Y. A good example is a model which, as it is never identical with what it models, is a heuristic device to enable understanding of what it models. In the form of a noun it describes an empirical rule, a procedure or a method, which is emphasized in schools and lakatianas Popperian philosophy of science, who value creative thinking and the construction of scientific theories. The following procedure will be presented by Lakatos systematic scientific research, which enables to understand the role of heuristics in a research program, from the most central theories, even the more general provisions of auxiliary hypotheses.

Lakatos transposes what he understands as a naïve falsificationism which tries to refute a theory in key punctual experiments, for what he understands how a more sophisticated falsificationism, which can only evaluate a theory inside a set of testing hypotheses; such a set is provided by the unity of a Scientific Investigation Program (SIP). Besides the prerogative of offering a rational historical attempt to reconstruct science, the SIP can be understood as a methodology (delineated from now on as MSIP). In Popper's methodology of falsificationism, one of the basic elements is preferred when accepting unique space-timely universal utterances; besides that, another basic element is that the theory must provide new facts which were not previously explained by the former theory, which forbids the employment of *ad hoc* hypotheses, i. e., hypotheses conceived just right after a trial whose aim is to 'save' the theory (Lakatos, 1998, p.28).

The tool of criticism used is the *modus tollens*, whose proprieties are: (i) to transmit the truth, from the *explicans* to the *explicandum*, if the premises are true, the conclusion is true; (ii) retransmit falsity, from the *explicandum* to the *explicans*, if the conclusion is false, at least one of the premises must be false and; (iii) not to retransmit the truth, from the *explicandum* to the *explicans*, if the conclusion is true, the *explicans* can be partially or totally false, for it is possible to extract true conclusions from false premises.

In MSIP the theory is not evaluated separately, yet it is done inside a structure of the SIP; such structure, as it is demonstrated below, addresses to heuristics. Popper's conjecture turns out to be a Lakatos' meta-conjecture; a theory is not seen any longer in its oneness, but it is seen then inside an intertwined system of theories which aims at solving a problem; science as a whole turns out to be an immense PI based on the supreme rule by Popper '*to propose conjectures which have more empiric content than their predecessors*' (Lakatos, 1989, p. 65). Instead of an instant refute, it occurs a process which can be too much long and which, considering the foreseeing and explicative advances of the auxiliary hypotheses against the anomalies, can be considered as progressive and degenerative.

2.1. NEGATIVE HEURISTICS

Lakatos structures the SIP from what he denominates as 'hard nucleus' which would characterize the essence of the program, composed by hypotheses which are unquestioned by methodological decision (Lakatos, 1970). He can or cannot include metaphysical utterances, which inhibits the use of the *modus tollens* for this nucleus and would displace its use to positive heuristics (Lakatos, 1989, p.66), which will be developed in the following section.

It can be considered as a conventionalist stratagem which aims at preserving the investigation program against immature refutes, allowing certain time of adjustment in order that the positive heuristics can respond to certain anomalies and the hard nucleus can demonstrate its explicative potential. It is conventionalist not in the justifying sense proposed by Poincaré, because the nucleus must be abandoned when it may not explain new facts, once they are explained by another more consistent SIP, it is similar to Duhem's conventionalism, but in the sense of abandoning the nucleus by aesthetics, yet because the nucleus can be abandoned by logical and empiric basis. (Lakatos, 1989, p.68). The 'hard nucleus', it means, the negative heuristics can seem essentially destitute of empirical test, once it is formed before the observation and it inhibits the test via *modus tollens*; however, it can be realistic and in Lakatos it gains relation to reality from the positive heuristics, which will make the SIP operational, as it will be explained bellow.

2.2. POSITIVE HEURISTICS

SIP negative heuristics emerges immersed in a sea of anomalies (Lakatos, 1989); the core nucleus thus is born refuted in front of facts which contradict it. In order to preserve this nucleus which can generate some explicative potential, it is created a sort of protection, i. e., *ad hoc* hypotheses derived from the nucleus and which try to accommodate the anomalies, reverting them, whenever it is possible, in elements which amplify more and more the explicative power the nucleus offers. Each step represents an increasing of empiric content (Lakatos, 1979, p.164). According to Lakatos (1989, p.69):

> *la heurística positiva consiste de un conjunto, parcialmente estructurado, de sugerencias o pistas sobre cómo cambiar y desarrollar las «versiones refutables» del programa de investigación, sobre cómo modificar y complicar el cinturón protector «refutable». La heurística positiva del programa impide que el científico se pierda en el océano de anomalías. La heurística positiva establece un programa que enumera una secuencia de modelos crecientemente complicados simuladores de la reahdad: la atención del científico se concentra en la construcción de sus modelos según las instrucciones establecidas en la parte positiva de su programa. Ignora los contra-ejemplos reales, los «datos» disponibles.*

It is necessary to make a distinction of what is understood as *ad hoc* hypothesis by Popper (2006) and how *ad hoc* hypothesis is a hypothesis which does not add nothing in terms of prevision, it reduces falsifiability of a theory and they are done in order to justify a determined result and just that; they are not independently testable, this kind of hypothesis is not admitted in falsificationalism. For Lakatos (1979), *ad hoc* hypothesis, understood inside the positive heuristics, should increase falsifiability, be independently testable and, when formulated, amplify the domain of explanations, embracing new unexpected facts.
It is the positive heuristics which determines the problems and the anomalies; the positive heuristics amplifies the explicative potential of the nucleus against the tests and it does not use the tests to corroborate for the creation of adjacent hypotheses which aim at explaining the failure of the tests. Therefore, one opts to denominate the *ad hod* hypotheses of the positive heuristics as auxiliary hypotheses. Inside the positive heuristics there can be also employed *ad hod* hypotheses in the sense given by Popper; nevertheless, the current use of such hypotheses is a signal of a program in degenerative state.

Presented the general notion of heuristics, the following topic will focus on the use of models focused on the positive heuristic, more broadly, with general models that can serve of subsidies to some theoretical systems for better didactic understanding.

MODEL CONCEPT AND HIS USE AS HEURISTIC PROCEDITURE

Can be considered a theory, a rule, a hypothesis, a structured idea, a function, a relation, an equation or a synthesis of data (Chorley and Haggett, 1974, p.3); they are generally employed as an adjective to exemplify a degree of perfection; as a noun to suggest a representation; or as a verb in the demonstration of how something is (Chorley and Haggett, 1974, p. 4). the models exemplarily are presented by Christofoletti (1999, p.8), in accordance with definition of Chorley and Haggett (1974) as:

> a simplified structuration of the reality that supposedly presents, in a general way, important characteristics or relations. The models are approaches highly subjective, for not including all the comments or measured associates, but they are valuable for overshadowing accidental details and allowing the appearance of the basic aspects of the reality.

They complement each other yet, according to Chorley and Haggett (1974, p.3), the geographical point of view, with the translations in the space of arguments about the real world, which will lead to spatial models, and on time, leading historical models.

It is important to place the main characteristics of the advantage of using models, and we have among the main *structuring*, which enables to select variables from reality allowing the exploration and understanding of the relations; *selectivity*, which guarantees an approximation with the real, analogies which make the aspects of the world more familiar, accessible, and explainable; and, *reapplicability*, which enables the test in the real realm of validity of the model against the phenomena that one aims at explaining, which guarantees a certain link with the presuppositions of the scientific method (Chorley and Haggett, 1974, p.5). The types of models can be grouped according to their purposes and ways of representing reality.

The three characteristics listed allow us to think the use of models as positive heuristic within research programs. Models are constructed because the complete theory would be very complex to work, thus the idealizations allow the scientist to produce significant results with limited resources (French, 2009, p.45). Amedeo and Golledge (1975, p.86) in this sense, define a model as "is an approximate representation of the structure of the relationships and interrelationships existing in the problem context."

In the heuristical process with models, French (2009, p.46), distinguishes three ways: (i) positive analogy, when the model in the base of some form of correspondence is established enters some property of the elements of the system and some properties of the object or the set of objects in terms of which if it is shaping the system; (II) negative analogy, properties listed in the model and do not represent properties of the system you are modeling, (III) neutral analogy, properties listed in the model of which is not sure whether or not submitted by the system you are studying. By exploring the analogy neutral, neutral properties in determining the model that remains in the system, you find new features of the system, there lies all the action of the discovery (French, 2009, p.46). In this process, the models are used as mediating between the theories and comments, a time that the complexity of great programs of inquiry becomes of difficult operation the hypotheses auxiliary, the model as ideal simplification, allows to abstract initial anomalies that would hinder the relation between the observed fact and the general theory. Amedeo and Golledge (1975, p.86), in this direction, defines a model as "*is an approximate representation of the structure of the relationships and interrelationships existing in it problem context*".

SYSTEMS BASED ON HEURISTIC PROCEDURE

According to Haigh (1985, p.195) five different traditions of systems thinking can be identified within geography: (i) a connected reductive nature of physical geography, (ii) the spatial analysis and use of models, (iii) of ecological systems, (iv) that the study evaluates the landscape and (v) that seeks to link the geographic systems of general systems laws. In all cases, the use of specific models may be a heuristic tool, however, the focus will be given lines (i) and (ii).

A system can be understood as an organized ensemble of elements and interactions among such elements (Christofoletti, 1999); in the scientific context it has been used as a representative form of reality. In general, systems appear in the geographic literature employed in the Theory of General Systems (TGS), according to Bertalanfy (1973). In this article, it is aimed at developing another conception of the employment of systems of that which is conventionally used in Geography. The proposal here is not to get into the discussion of such theory (TGS), but to employ systems as structuring of knowledge, and not as a form of a new paradigm; the paradigm continues to be the hypothetic-deductive, based on Popper's critic rationalism. To understand and visualize a world in the form of systems claims the construction of variables of such systems, and, consequently, it makes the advancement of the necessity of molding. The main objective is to present a heuristics which makes clear the systems through models, mainly the ones which emphasize aspects of time and space.

An initial path possible for the heuristic model systems is the definition of the system itself, an arbitrary procedure that takes into account the type of problem that you want to deal with and the type of relationship you want to value. Christofoletti (1999, p.51) shows that the need of defining the limits established their system, allows us to understand the structure and behavior, making it something identifiable and capable of analysis, shows that "the boundaries of the system must distinguish between its components and elements of other systems, taking into account the morphological characteristics as the context of hierarchical nesting quantities in space. "This point in delineating the boundary between two systems is an important component for implementing heuristic.

Applying the heuristic systems can be considered the same way as described in the model comparison. When considering two systems (S1 and S2) whose structure and behavior are known in terms of connections, relationships and outputs, Harvey (1983, p.467), draws attention to the possibility of establishing ways in which S1 can be similar or distinct from S2, so it is possible to determine under what conditions S1 S2 model can be either the structure or the relationships, "*es por ello importante distinguir caules son los aspectos que estamos integrando em el modelo, si estamos incluyendo su estrutura, su comportamento o el sistema como um todo*" "(Harvey, 1983, p.467).

Harvey (1983) and Klir citing Valachi (1967, p.108) presents an important distinction when using modeling as heuristic systems, the concepts of isomorphism and homomorphism. According to Harvey (1983, p.468):

> Dos sistemas serán isomórficos si los elementos em *S1* pueden asignarse unicamente a los elementos em *S2*, y viceversa, y si para cada relación (rij) em *S1* existe uma relación exatamente similar em *S2*, y viceversa. La relación isomórfica entre dos sistemas es simétrica, reflexiva y transitiva (...) Dos sistemas son homomórficos cuando los elementos em *S1* pueden asignarse unicamente a elementos em *S2*, pero no viceversa, y las relaciones em *S1* también pueden asignarse a relaciones em *S2*, pero no viceversa.

By defining the system and keep in mind the main heuristic device, you can have some procedures as a guide for the construction of models. In this sense, are the fundamental questions posed by general Polya (1957) when dealing with the foundations of heuristics: (i) understand the problem, (ii) establish a plan for the solution, (iii) execute the plan, and (iv) check the adequacy of the response. As procedures guide, Christofoletti (1999, p.25) notes: (a) *goals*, purposes of the model to be built (which is the system to be modeled? What are the main issues to be focused on the model and what is the rule for complete the activity of modeling? With which other models it should be compared? As the outputs will be analyzed?) (b) *assumptions*, goals and transform the available knowledge of the system in statements of assumptions, (c) *mathematical formulation* (when possible) present the hypotheses and assess formally the equations that describe the dynamic behavior of the system elements and processes, (d) *verification*, set of activities to verify the accuracy of statements and equations, using numerical techniques or functions heuristics, (e) *calibration* is to establish parameters for the inputs and internal conditions of the system in order to verify the adequacy of responses.

CONSIDERATIONS

The model concept can be used in various approaches, including science. In scientific models assume a central role in mediating between broad theories and reality. The geographer, which aims to understand problems related to spatial issue of the phenomena that occur on Earth's surface, the model becomes an important element, since it has as one of its main functions to perform this mediation.

Within the framework of Lakatos for scientific research shows there is a better understanding of what is to be heuristic, and how it plays an important role in large research programs and theories. In this perspective, the models fall as heuristic devices ideal and worked in the way of structuring systems can provide a powerful mechanism for understanding problems. The field for this application in geography is immense, whether by the physical, human or even adding the relations between these two.

REFERENCES

Amedeo, D; Golleedge, R. G. (1975) *An Introduction to Scientific Reasoning in Geography*. New York : John Wiley & Sons.
Chorley, R. J.; Haggett, P. (1974). *Models in Geography*. London: Methuen.
Christofoletti, A. (1999). *Modelagem em Sistemas Ambientais*. 1° ed. São Paulo: Edgard Blücher.
French, S. (2009). *Ciência: conceitos-chave em filosofia*. Porto Alegre: Artmed.
Haigh, M. J. (1985). Geography and General System Theory, Philosophical Homologies and Current Practice. *Geoforum. Special Issue: Links between the natural and social sciences*. v.16, n.2, p.191-203.
Harvey, D. (1983). *Teorías, leyes y modelos en geografía*. Madrid: Alianzaa Editorial.
Lakatos, I, and Musgrave, A. (1979) *A crítica e o desenvolvimento do conhecimento*. São Paulo : Cultrix.
Lakatos, I. (1989) *La metodología de los programas de investigación científica*. Madrid : Alianza Universidad.
Polya, G. (1957). *How to Solve It*. New York: Doubleday.
Popper, K.R. (2006) *A lógica da pesquisa científica*. São Paulo : Cultrix. 12ºed.