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Construction of scientific knowledge
Some reflections on a cultural process

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Abstract
Within the scope of the sociology of science, it is proposed a brief "state of the art" that promotes the interest in understanding, to describe, analytically, a scientific work group, as a unit of investigation and production of scientific knowledge. Proposing that research based on observation methodology allows for investigation in depth, seeking to access some of the dimensions that are part of the process of construction, production, and reproduction of knowledge around a cultural standard.
Keywords: paradigms; collective thinking style; scientific socialization processes

Construção do conhecimento científico
Algumas reflexões sobre um processo cultural

Resumo
No âmbito da sociologia da ciência, propõe-se, um breve "estado da arte" que promova o interesse em compreender, descrever, analiticamente, um grupo de trabalho científico, como unidade de investigação e produção de conhecimento científico. Propondo que a investigação baseada na metodologia de observação, permite investigação aprofundada, buscando acessar algumas das dimensões que fazem parte do processo de construção, produção e reprodução do conhecimento em torno de um padrão cultural.
Palavras-chave: paradigmas; estilo de pensamento coletivo; processos de socialização científica

Construction de connaissance scientifique
Quelques réflexions sur un processus culturel

Résume
Dans le cadre de la sociologie des sciences, un bref «état de l'art» est propose qui favorise l'intérêt pour la compréhension et la description analytique d'un groupe de travail scientifique, en tant qu'unité d'investigation et de production de connaissances scientifiques. Proposer que la recherche basée sur la méthodologie d'observation permet une enquête approfondie, cherchant à accéder à

certaines des dimensions qui font partie du processus de construction, de production et de reproduction des connaissances autour d'une norme culturelle.
Mots-clé: paradigmes; style de pensée collective; processus de socialisation scientifique

Construcción del conocimiento científico

Algunas reflexiones sobre un proceso cultural

Resumen
En el ámbito de la sociología de la ciencia, se propone un breve "estado del arte" que promueva el interés por comprender y describir analíticamente un grupo de trabajo científico, como unidad de investigación y producción de conocimiento científico. Proponer que la investigación basada en la metodología de la observación permite indagar en profundidad, buscando acceder a algunas de las dimensiones que forman parte del proceso de construcción, producción y reproducción del conocimiento en torno a un estándar cultural.
Palabras clave: paradigmas; estilo de pensamiento colectivo; procesos de socialización científica

Introduction

This reflection falls within the scope of the sociology of science, which is interested in studying the *locus* of construction of scientific knowledge, privileging intensive analysis, based on the research tradition of cultural anthropology and symbolic interactionist, phenomenological, and ethnomethodologically sociologies[1]. It seeks to give rise to a scientific product of an essentially qualitative nature, on a group of individuals, presupposing the researcher's direct and prolonged contact in the field, interacting with people and situations, implying the critical organization of research practices in a movement of articulation between concrete observations, local knowledge, and models of interpretation.

The purpose is to observe a culture through its praxis. Detecting and identifying the presence of signs characteristic of a scientific work group. In addition, how they are present in the different social processes that occur in the scientific practice of its elements, giving expression to a cultural configuration and specific identity[2].

[1] Although framed within programmatic evolutions of their own disciplines, they have transdisciplinary dimensions that guided us in this observation work. Cultural anthropology requires a fieldwork spending an extended period of time at the research location. Symbolic interactionist alludes to humans' particular use of shared language to create common symbols and meanings for building the product of interactions; how individuals interact to create symbolic worlds, and how these worlds shape individual and collective behaviours. Phenomenology revisits the importance of phenomena with the purpose of discovering existential structures of individual and collective acts. Ethnomethodology is the study of how social order is produced in and through processes of social interaction.

[2] Cf. Crane (1972) which, long before the development of relativist and constructivist currents, highlighted the importance of framing studies in the sociology of science within a much broader scope, that of the *sociology of culture*, as a way of also avoiding excessive isolation of the sociology of science.

Cultural standards, which are the basis of scientific conduct, are responsible for *worldviews* due to socialization processes and the possibility of interdisciplinary interactions. An adequate qualification of the social nature of scientific knowledge and the interactive practices of scientists becomes imperative[3].

In a return to the historical-philosophical agendas of Thomas Kuhn[4] and the structural-functionalist agendas of Robert Merton[5], the study seeks to articulate, essentially, the historical perspectives of science and knowledge[6] and the constructivist perspective of the sociology of science[7]. Aspects related to analytical perspectives connoted with other schools and visions[8] and, in some way, surface aspects that are more directly related to the sociology of organizations[9] and the threads of the sociology of science that, in one way or another, are concerned with issues related to scientific activity as a specific form of work[10].

The reflection now presented is part of a case study carried out by the author, with a scientific working group, within the scope of Theoretical Physics, based on the Theory of Relativity.

1. Theoretical-methodological reflections for observing scientific practice

In one of the many versions written about the dynamics of the sociology of science during the last two decades of the 20th century (Martinez et al., 1994), we gave the perspective of the successive developments and demarcations of perspectives, schools, and research currents. From the strong program, in the version of Bloor (1976), or the relativist version of Barnes (1974), to the program of social constructivism and methodological relativism of Collins (1982), Collins and Yearley (1992), Pinch (1990; 1992) or Pickering (1982). From the relativist analyses of scientific discourse by Mulkay (1991) to the constructionism of Knorr-Cetina (1982), from the theory of actor networks by Callon and Latour (1991) to the reflexives' of Woolgar (1988) or Lynch's ethnomethodology of science (1985).

This dynamic has been incorporating a set of research - called laboratory studies, of anthropological inspiration - which differ from previous studies, especially in the methodology used. On the one hand, these studies choose scientific practice as the object of observation, considering

[3] Focusing, in this way, on the issue of social networks, in a line of analysis also introduced by Diana Crane (1972).
[4] Kuhn (1979; 1982; 1983; 1989).
[5] Merton (1968; 1970; 1977).
[6] Kuhn (1979; 1982; 1983; 1989); Holton (1988a; b; 1998).
[7] Knorr-Cetina (1977; 1981).
[8] Bourdieu (1976).
[9] Mintzberg (1982); Peters and Waterman (1987); Crozier and Friedberg (1977).
[10] Yearley (1993); Patrício and Stoleroff (1996).

that this is the only way to account for how scientific knowledge is constructed, and, on the other hand, they consider that such an objective can only be achieved through observation, directly and participating in the daily work of scientists.

Direct contact with knowledge producers, with their "rituals" of production and transmission, has become important to understanding which mechanisms underlie scientific production. As Latour and Woolgar (1979) refer, although our knowledge about the external effects of scientific activity may have increased, our understanding of the "complex activities" that constitute the production process of scientific activity remains to be developed. If we currently have more in-depth knowledge about the rites and myths of exotic tribes, it was because there was direct contact between researchers and these tribes. However, in current societies, we seem to remain relatively ignorant about the details of equivalent activities between groups of scientific production.

Therefore, a double effort becomes necessary: to penetrate the "rituals" that characterize scientific life and to provide a reflective understanding of the details of scientific work, according to a hybrid vision of intellectual, technical, and social activities, mutually dependent and influencing each other (Woolgar, 1988; Knorr-Cetina, 1982).

An important change that occurred in traditional sociological research methods and which was led by Edge and Mulkay (1976), whose study on the emergence of radio astronomy in England, contributed to this perspective of understanding scientific activity, due to the competition of technical and intellectual strands.

With an observational strategy thus defined, its defenders (Knorr-Cetina, 1981, 1982, 1995; Latour and Woolgar, 1979; Callon and Latour, 1991; Lynch, 1993) consider that the sociology of scientific knowledge will be able, for the first time, to cancel the social/cognitive, or exterior/interior dichotomy. Which, from his point of view, does not happen in certain disciplinary studies, based for example on the analysis of scientific controversies, as they begin by isolating and describing the cognitive problem, and then identifying the social factors that relate to it. On the contrary, in the case of laboratory studies, these distinctions and dichotomies are understood as being the result of "construction processes" anchored in the concrete practices of scientists, which are therefore chosen as a fundamental element of observation.

However, the foundations of the sociology of science, from any perspective, relativist, and constructivist, do not separate knowledge, about the substantive issues of scientific theories, and the social actors who participate in their production.

From a relativist sociological perspective, the nature of scientific knowledge is, significantly influenced by the contexts of production, implying the consideration of scientific practice as a particular form of work (Yearley, 1993). Having, after all, studies of scientists' practices, as a goal, the "integrated understanding" of all aspects of doing science: planning and processing, construction instruments, configuration of research instruments, quantification and transcription of results, elaboration of theories, debates with colleagues, stabilization of knowledge (Pickering, 1982).

The affinity between relativist and constructivist perspectives can be explained by common intellectual influences.

Nevertheless, the constructivist perspective seeks to take a step forward with simply descriptive perspectives of doing science, based on the thesis that scientific products are specific constructions, contextually situated, around contingency, situational, and structural (Knorr-Cetina, 1981; 1982)[11].

Based on the aforementioned studies, in the sociology of science, lately, instead of asking the general question of the relationship between science and society, it prefers to observe the specific contexts in which science is produced, expanding a line of investigation that already had, however, been initiated by Robert Merton (1970) and Thomas Kuhn (1983).

Merton - recognized as the founder of the sociology of science - in addition to analyzing the influence of society on science, and then the influences of science on society, was also concerned with how social factors participate in the construction of scientific facts (Merton, 1977). He also dedicated himself to the analysis of the social relations internally constitutive of scientific institutions and scientific production processes. Worrying about the mediations between theory and the possibilities of analysis in diverse sociocultural contexts, and with the contradictions and conflicts in the structures and the ambivalences in the motivations and perceptions of the actors, implying, from this point of view, a concern with the contextualization of scientific production (Martinez *et al.*, 1994; Zuckerman, 1988).

Kuhn, after Merton, and like him, would become a reference of undeniable importance for the sociology of science. Especially within the scope of the history and philosophy of science, it produced a schematic and strongly heuristic model for sociology that is concerned with the sociocultural and sociocognitive interactions present in research practices and the structuring processes of scientific communities, and theoretical change that occur in them (Kuhn, 1983; 1989).

Kuhn's theory reaches the positivist conception of the unity of science and its constant cumulative progress: it effectively shows that such knowledge proceeds discontinuously, through successive changes in paradigms.

[11] See, also, Traweek (1992).

Acceptance of the heuristic capacity of a paradigm requires the evaluation and orientation of the problems offered to scientific research and the criteria according to which experts decide on what should be considered an admissible problem or a legitimate solution.

Kuhn's model has had an impact on the sociology of science, constituting a reference point for analytical perspectives whose main focus is the observation and interpretation of research practices carried out by scientists, as well as the processes of producing scientific statements, taking into account determined social contexts and characterizable social processes. In the words of Callon and Latour (1991), it could be said that Kuhn's proposals aim at an understanding of "science as it is done".

The protagonists of this current sociology of science have been developing sociological investigations of the social processes of the production of scientific knowledge. The strong point of this current lies in the construction of objects of analysis that allow the sociological understanding of this particular social sphere that is science, as well as the processes and products of scientific research, and the development of observational research strategies of contexts and agents.

The problem of the contextual organization of scientific action has been posed in terms of two distinct questions: the first refers to organizational units, and has generally been answered by research in scientific communities; whilst the second refers to the integration mechanism that characterizes the respective communities.

The characteristics of the different communities of scientists. The forms of organization of scientific laboratories, the formal and informal interactions between participants and the influence of relationships with interests outside of science, the communicative processes and forms of contact between scientists have already been subjected to careful analysis (Latour and Woolgar, 1979; Knorr-Cetina, 1981; Knorr-Cetina and Mulkay, 1983; Gilbert and Mulkay, 1982).

Since the first sociological conception of science, answers to the second question have been dominated by economic analogies. The development of these analogies highlights a postulate of relatively isolated economic mechanisms - a metaphor for competition.

Merton was one of the first to use the idea of quasi-economic competition. The idea was developed in his study of struggles over the priorities of discoveries, and later redefined in his work on the "Matthew effect" (Merton, 1968) to mean imperfect competition - that is, recognition goes to those who already have the reputation established, illustrating that it is those who have the most who receive the most. It shows how in the scientific universe reward distribution systems tend, due to their structural functioning, to accentuate inequalities[12]. He also shows how, in the scientific field,

[12] On the structuring of scientific capital, see (Ávila, 1997), which confirms the strong stratification of the

the capital of scientific recognition achieved tends to self-reproduce and, correlatively, its lack can tend to negatively self-reproduce (Merton, 1977).

The line of investigation introduced by Merton underwent many developments, especially from the mid-1960s onwards. Among the set of works that were carried out at that time, it is worth highlighting that of Hagstrom (1965) on the logic of structuring scientific communities and the specificity of the reward system, that of Ben-David (1971). On the development of the social role of scientists and the evolution of forms of organization of scientific institutions, Crane (1972). On communication patterns in science and their relationship with the development of scientific communities, referring to the so-called "invisible colleges" as a way of seeking prestige (Cole and Cole, 1973) on social stratification in science, Zuckerman (1977) on Nobel Prize-winning scientists, among others.

The explicit use of the pre-capitalist model can be found in Hagstrom (1965; 1982), who sees the normal functioning of scientists according to a mechanism in which scientific acquisitions are "exchange currency" in favor of specific rewards. This exchange mechanism is more directly related to the idea of "gift-giving" in normatively integrated communities, than to the idea of maximizing profits in an antagonistic market.

Reiterations of the basic ideas of this model can be found in several other authors - notably, Storer (1966), who saw science as a form of art for art's sake. Storer combines an archaic exchange model with the notion that science is the answer to the desire to create, which is already found in human nature.

The transition from a pre-capitalist exchange model to a capitalist market model appeared ten years later at the hand of Pierre Bourdieu (1976). The scientific field is no longer seen as a community of experts competing for creative achievement but as a place of a competitive struggle for the monopoly of scientific "credit".

The concept of "credit" should not be confused with that of "recognition" advanced in early studies. "Recognition" has been defined as a specific form of reward, and concerns the operation of a system similar to the psychological stimulus-reward situation.

By contrast, "credit" is defined as symbolic capital acquired by scientists through the imposition of technical definitions and legitimate representation of scientific objects in the field. Such capital is composed of scientific skills and social authority, and like monetary capital, it can be converted into all types of resources necessary for the continuation of scientific production.

scientific field in terms of scientific capital, at entry, and its form of accumulation in the field.

While "recognition" functions as a selector to find the best scientific behavior in an essentially cooperative universe that seeks for the system to maintain itself, Bourdieu's symbolic capital "credit" governs the market in an essentially antagonistic universe.

Latour and Woolgar (1982), to refer to capital production, propose the notion of "credibility" instead of "credit". From this perspective, scientists invest in fields and topics that promise a better return. The credit they earn for producing more or new information is used to reinvest, which means that scientists, in addition to being interested in the subject they investigate, or in the production of more information, for its own sake, also have an interest in the acceleration and expansion of the reproductive cycle ("credibility cycles") which produces new and credible information.

Pickering (1982), in turn, states that scientists want to have the conditions to continue producing knowledge, contextually situated and constructed. However, it does not call into question that the interests described by Hagstrom, Merton, and Latour, can be considered genuine interests of scientists, namely "recognition", "credit" of scientific capital, "credibility", "competition", highlighting the "ambivalence" necessary for the adoption of possibly different strategies, proposed by Lemaine (1980).

From this perspective, scientific production to be understood cannot be seen as an abstraction that has nothing to do with social activities, as Merton (1977) already mentioned. In this sense, according to the same author, priority disputes, for example, should not only be explained by the personality characteristics of individual scientists but also by the institutional and organizational dimension of science that defines originality as the supreme value[13].

Thus, what happens in the knowledge construction process is not irrelevant to the products obtained, which have to be seen as products internally structured by the production process itself (Knorr-Cetina, 1981; 1982).

For Kuhn (1983), who in many ways takes up the philosophical perspective of Ludwig Wittgenstein (1889-1951), all knowledge has a social root. Insofar as all learning derives, either from what is already indicated as universally accepted, or it arises through the use of rules and definitions that, by expressing meanings in the paradigmatic scope, are themselves, when referred to other rules and definitions, ultimately based on relationships of similarity apprehended through a very vast set of generally accepted examples.

If we define collective thought as a community of people exchanging mutual ideas or maintaining intellectual interaction, we will find by implication that this also provides the path for

[13] See the perspective of scientific controversies in Bruno Latour, in terms of the process of scientific construction on a micro sociological scale (Latour, 1984; 1989).

the historical development of any field of thought, as well as for acquired knowledge and scientific styles (Fleck, 1981)[14]. In this sense, cognition depends on a social process and, as a result, someone recognizes something in terms of a certain cultural background, or better, as a member of a cultural environment, and even better, in terms of a particular collective thought.

Kuhn already indicated that knowledge is always a phenomenon of conventional communication, which develops within determined contexts, based on practical agreements, which are also tacit, through which the specific uses of terms emerge and the various phenomena are framed, both the usual and the new and unexpected. Therefore, scientific knowledge is acquired through training within a system of conventions, which originate in cognitive processes, including judgments and agreements, and develop over time.

In this sense, it becomes pertinent to appeal to the perspective of the historian of science, Gerald Holton (1988a,b; 1998) who, by introducing the concept of *thémata* and its stylistic interdependence, contributed to circumscribing creative freedom in science, as well as the direction and the pace of progression over new terrain[15].

From his point of view, all fields that claim or claim to be scientific try to project their concepts, formal conditions, and problems onto the Cartesian x-y plane, emphasizing phenomenal and analytical-heuristic aspects. However, to supplement the analysis limited to the x-y plane, Holton suggests thematic analysis in science. Thus, in addition to the empirical or phenomenal (x) and analytical-heuristic (y) dimensions, he defined a third dimension or z-axis.

This third dimension is the dimension of fundamental presuppositions, notions, terms, methodological judgments, and decisions - in short, of *thémata* or themes, with more connection to the idiosyncratic dimensions of doing science. Thematic imagination will consist, in practice, of letting a fundamental presupposition - a *théma* - act as a guiding thread in the work of a researcher even if, sometimes, he does not have evidence to support it and, sometimes, even in the face of to instances that seem to contradict it, in this case, in an attitude of voluntary suspension of non-adherence.

Case studies show that choices and decisions of this type are often processed against the backdrop of a faithful anchoring of thematic assumptions (Holton, 1988a).

[14] On the issue of styles of thought, from an anthropological perspective, cf. Douglas (1996).

[15] Another perspective from the history of science on this issue, also based on the analysis of the genius Einstein, is that of Miller (1982; 1984; 2014). His analytical perspective, with great interest in understanding and explaining "mental models" in scientific creativity, refers to cognitive aspects, the role of visual images and the relationship between conscious and unconscious ways of thinking in Problem solving. At the same time, it also develops an interesting reflection on the way Einstein distinguished, or sometimes confused, the context of discovery (Popper, 1959) and the context of invention.

Figure 1 – Collective thinking style.

G r o u p C u l t u r e
⇑
⇓
COLLECTIVE THINKING STYLE

NORMAL SCIENCE

PARADIGM(S)

x-y plane
determination of significant facts
agreement of facts with theory
elaboration of theories

z-axis
thémas
assumptions

professional specialization
⇓
Socialization processes

***thémas* adopted/*a priori* assumptions**
⇓
Sociocognitive networks

⇓

(*Scientific imagination-creativity*)
Study objects

⇓

Communication Systems

Sharing validity criteria
-values-interests

⇑
⇓
RESEARCH TRADITION

Source: The author, Carmen Diego Gonçalves.

The thematic analysis therefore consists of determining a particular letter of the various *themata* that, like fingerprints, can characterize a scientist taken in isolation or a part of the scientific community, at a given moment. Armed with this conceptual tool, the researcher will be able to seek to establish the assumptions that underlie scientific production, even if scientists are not generally aware - and do not need to be - of the *thémata* they use.

Any scientific discourse therefore starts from theoretical assumptions that do not reproduce facts in themselves, but are the product of the organization of experience and its interpretation, within a framework oriented according to pre-constituted meanings, by the reference paradigm.

In turn, and based on Habermas's (1986) theory of communicative action, we can consider that any expression of linguistic acts is based on validity requirements, that is, on reasons and legitimation references that give guarantees about the contents that are communicated.

For Habermas, there are three fundamental types of validity requirements: truth, to satisfy existential demands corresponding to the objective world; correction, aimed at legitimizing the normative context of discourse about the social world; sincerity, referring to the subjective intentions of the speaker and corresponding to the subjective world.

Habermas thus proposes the distinction between action-oriented toward understanding, which is developed, through language, based on rationally motivated agreements about specific validity requirements, and action-oriented towards success, which includes the forms of instrumental action, or technical, "non-social" action, and strategic action, of a "social" type.

Accepting the aforementioned assumptions is admitting that the agent plays an important role in achieving prestige, visible in the more or less favorable comments about his work. In this sense, individual strategies will essentially refer to the adoption of communication logics where, predominantly, the tendency to reproduce a style of collective thinking will be inscribed, giving successive proof that it is up to accessing the different levels of recognition and obtaining scientific authority, in a logic that combines cognitive and instrumental interests.

From this perspective, scientific production is an activity of social construction, resulting from a series of social and cognitive activities. In this way, the social character of science is legitimized and it is demanded that its analysis equates in the same system the shared validity criteria, values, and interests that guide the activity of scientists in terms of disciplinary culture.

Conclusions

We are seeking an analysis that examines the relationship between scientific research processes and their resulting products, taking into account disciplinary, cultural, and communicational factors. Considering as the main factor, in the analysis plan, the *locus* of construction of scientific facts and theories, which provides the means of understanding the organizational factors of scientific activity, in function of paradigms and rational specificities and the nature of scientific tasks. An analysis that examines the relationship between scientific research processes and their resulting products, taking into account disciplinary, cultural, and communicational factors., having as its basic assumption the themes and assumptions that motivate individual creativity, enabling socio-cognitive interactions within the scope of a collective *thinking style*.

Seeking to understand, to describe, a scientific research workgroup allows us to identify many possible dimensions of analysis, within the scope of the sociology of science, but which, as they go beyond the scope of this reflection, have not been deepened or even considered here. However, clues for possible future work are recorded.

Thus, it would be interesting to design studies that would deepen: (a) the problem of Kuhn's concepts of "paradigm" and "disciplinary matrix", seeking to articulate the perspective of "fuzzy logic", used by us, with the perspective of research programs of Lakatos (1983). Developing the articulation between "positive heuristics" or "hard-core" and a "negative heuristics" associated with research programs, indicating the lines of investigation to be pursued and the recommended methods, seeking to integrate different theoretical perspectives to interrelate and deepen the concepts of "trans epistemic arenas", "socio-cognitive networks", "translation", "sharing". (b) The aspects that relate to the importance of the contexts of discovery, justification, and invention for the production of *types* of scientific knowledge. Seeking to articulate the different types of imagination (thematic, visual, metaphorical) referred to by Holton, this by reference what, for example, theoretical physicists who work with the theory of relativity, call "the famous intuition in physics", closely related to mathematics. (c) The importance of schools, styles, and leaders for the production of scientific knowledge, seeking to deepen the changes, so to speak, that these concepts have registered over time and what factors, contingent and idiosyncratic, have contributed to this.

As a brief overview based on fieldwork, this work will be further developed to structure the historical evolution of the proposed themes and each of the perspectives studied by different groups or tendencies of the sociology of science and knowledge. The reflection will be enriched by presenting other equally important models, highlighting, in particular, the social actor within the framework of symbolic interactionism, how the theories of networks were born, namely in Michel Callon, making this work more complete and complex according to the state of the art of sociology of science and knowledge in its conceptual and historical evolution.

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