

The translation of the chemistry's course: a dead or alive science?

RESUMO

The Scientific knowledge is built in scientific communities and, in Brazil, it is concentrated in the universities. Within this environment, different relations permeate, cross and fold their subjects, subjectivated by assemblages and discursive and normalizing practices. Analyzing how such communities form and expand their territories means, at the same time, observing how they remain alive. One of the strategies that allows us to observe this is to follow the Scientific Facts that circulate and oxygenate such communities. Going through the chemistry field leads us to analyze classrooms, chemical and research laboratories, students and teachers, human and non-human actors. Our research was carried out through the discourse analysis of interviews conducted with university teachers of the Chemistry course. Therefore, what we found was a “black box” full of tangled mechanisms that would guarantee its success. In this sense, the use of the Actor-Network Theory helps us to understand these flows and thus diagnose an alive or dead science, which will be able to be ascertained only by opening such a box.

PALAVRAS-CHAVE: Laboratory. Actor-Network Theory. Chemistry. Scientific facts. Latour.

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INTRODUCTION AND THEORETICAL PERSPECTIVES

As researchers of science education, our concern is on how science and scientific knowledge were and have been built, as well as how students in different education levels have access to it.

In this article, we focus on the relation between the knowledge production in university laboratories and its reach in Chemistry undergraduate classrooms. It is important to study the structure of the scientific community to understand this process, since it is this community that makes the scientific knowledge.

Brazilian research is structured in the triad teaching-research-outreach¹ for higher education institutions both in undergraduate and graduate courses. In this sense, we infer that there is only a gradient of conceptual data, procedures, and attitudes that differ undergraduate and graduate students, as most activities within the university concern both publics.

Therefore, when looking at most professors, we are looking at scientists, and it is not useful to distinguish undergraduate or graduate professors. They are university professors or, more precisely, professor-researchers, at least in the context of most Brazilian universities.

Although science is consolidated in academic seats, in the beginning of modern science, in the 17th century, it was made outside the universities². Insofar as science consolidated itself, it created its own institutions, such as the Royal Society of London³ and other research institutes (MAAR, 2004).

Nowadays, scientists do not work in isolation, they integrate a community, share interests, goals, concepts, and methods. Thus, scientists have to attract and recruit new colleagues to legitimate their production, building new disciplines, lines of research, and areas or fields of knowledge (PRICINOTTO, 2012; PRICINOTTO; OLIVEIRA, 2016a, 2016b).

Scientists, as creators, and their production, as creatures (theories, technologies, objects, and disciplines), when facing this multiplicity are not central and autonomous subjects anymore because they became a decentered and system-dependent subjects (both of objects and subjects).

The understanding that there is a researcher/scientist subject agrees with theories that emphasize the existence of a collection of subjectivities that interpellate us and creates a subject space. In this sense, it is important to look at the science under the perspective of Michel Foucault's discursive theories, as an empty space in discourses, a form, a space in which we accommodate, comfortably or not, and which constitute us in the relations and practices experienced, which are in constant transformation.

The scientist/researcher subjects from the Middle Ages, the Modern or Contemporary ages are not the same. Changes occurred in their practice, their relation with society and funding agencies, their interaction with partners and their future pupils. Therefore, we consider that such individuals nowadays, as indicates Latour, compose a socio-technical network.

Beyond the subject space or its form, whose theoretical support we find in Foucault's archaeology, we need a theoretical perspective for analysts of science

networks. With this aim, we resort to Bruno Latour's studies and his anthropology of science in action.

As states Latour (2000, 1997), one is no more or less scientist than those within or outside the laboratories; thus, science flows and permeates the practices and the subjects⁴. In this manner, science's flow to society is not clear, neither are the reagents that conduct to the hybrid product: Science&Society (S&S). Here we have a "black box"; even if it was transparent as a "glass box", it is untouchable and inexorable in its interior.

Other proposals to bring science and society close together are known as STMS – Science, Technology, Market and Society⁵, and STSE – Science, Technology, Society and Environment. These proposals make clear that more connections are increasingly needed to extend science's rhizomatic connections.

Thinking about academic research and teaching practices' structure permits the analysis of the knowledge/power relations that permeate teaching-research-outreach spaces. More connections, agencies, and interactions that were necessary to connect science with the broader society should be untangled.

Besides the hybrid Science&Society, we can cite another hybrid: Science&Technology. It is a review of the technoscience concept (CASTELFRANCHI, 2008; LATOUR, 2000), in which there is a flow from science, passing through research, and finally reaching technology. This flow attends market demands, military or governmental, which, by their turn, return (or should return) to society structures promoting social well-being, life quality, progress, among other advancements. Therefore, we may speak of the indissociable relation between S&S, but we cannot split the "black box", neither look into the "glass box".

To draw the science flow, or web, or "rhizome" (approaching Deleuze and Guattari), or even a "network", Bruno Latour⁶ invites us to think about the existing relationships between subjects and objects, which he calls "humans" and "non-humans", analyzing the two poles created by modernity: objects and subjects; nature (laws) and human (laws); science and society.

Not treating the network as a connection of heterogeneous actors, Latour deals with the most relevant point for science: the construction of the "scientific facts" (LATOUR, 1997, 2001). These facts are a part of the "network" and circulate through it as sap through the "rhizome". Either carrying nutrients or oxygen in human veins, this flow makes structures alive, or dead when they are not irrigated with sap, blood, and oxygen. Without a careful analysis, it is impossible to know if structures are still pulsing or are waning.

University institutions, places where science is produced, in Brazil are sustained by three axes: research, teaching, and outreach. Therefore, researchers, professors, outreach students cross the same subject, i.e., being a scientist in Brazil is to research, teach, perform outreach and administrative activities.

In this study, we trace the forms of scientist subjects of an academic community, analyzing their teaching practices within this community, following professor-researchers and the science in action.

Hence, our goal is to comprehend the practices within a group, an institution, a community, a (scientific) society, a laboratory and its knowledge production dynamics in the university environment. With this aim, we use the case of the

Instituto de Química (IQSul - Chemistry Institute), in the south region of the country. This institute is the stage of many events that, concerning chemistry, have produced innumerable relevant scientific facts in Brazilian science scenario, with implications on the teaching practice.

A "NETWORK": A PROPOSAL ABOUT THE "NON" MODERNITY IN SCIENCES

This analysis intends to follow and understand what Latour calls the Actor-Network theory and his comprehension of modernity and nonmodernity⁷. Latour's view focus on these two movements, proposing a set of "purification and translation" practices, conducted in what we may call the scientific Laboratory practice. A theory emerges in which "human" and "non-human" entities are actors, listed and connected through "translation", forming a "network" that announces their research effects as trustworthy mediators.

Therefore, it is necessary to understand the first twist proposed by Latour (2012, 2001) in his works: redefining the social. The social comprises not only the "human" entities, but also the "non-human", and, as aforementioned, they form a collective.

We currently experience an appropriate example for this view: the Covid-19 pandemic. Its beginning mobilized all the possible spheres. Being a lethal virus (a non-human actor), it drastically affected our daily practices. Since isolation was imperative, it modified our relationships and work (face-to-face/remote) and brought to light discussions about science denialism (practices of divulgation and social validation), population sanitary safety concerns, administrative and international relations challenges, conspiracy theories, universities, schools, physicians, hospitals, computers, telephone and internet providers, journalists, scientists, and science educators.

The list goes beyond the items mentioned. Nowadays, more than ever, we seat in front of cell phones and computers (non-human entities) to interact with others, study, or work. All these entities are part of the "social", according to Latour, in which each actor has an important role in the socio-technical network. Emphasizing the example, the pandemic is a socio-technical network where the scientific education is extremely connected in its links (Viana et al., 2020).

According to Rezzadori & Oliveira (2018, 2016, 2011), looking at chemistry and chemistry education with Latour's lenses is to make objects visible, not restricting only to humans/subjects the capacity (and responsibility) of changing the world. Objects are mostly produced with the aim of interfering in human life and practices, remembering, for instance, that technologies are extensions of scientists' bodies. According to the authors, it is extremely important to think about the hybridization between subject and object because objects have agency and mediation, combine interests, and increasingly associate actors and heterogeneous elements.

By its turn, Latour (1994, p. 16) states that there is a purification practice that "would establish a partition between a natural world that has always been here, a society with predictable and stable interests and stakes, and a discourse that is independent of both reference and society". The analytic partition, or purification, is necessary for science in vitro (i.e., analysis by mixtures decomposition), but

becomes effective only as a scientific fact through hybridization, which is in itself a translation of the research. We can understand that laboratory science creates a purified universe in which, supposedly, one thinks objectively. However, when the scientific fact is communicated, it is hybridized in translation.

In this manner, objectivity is the act of creating objects, but the one who creates objectives is a subject. Thus, another analytic possibility is to knot again the gordian knot⁹, connecting the threads that were cut, the threads of scientific knowledge, of societies and discourses. This combination is the path of the hybrids, built with translation/displacement practices. This new combination has not produced anything new because hybrids always existed, as seen in the quote mentioned before, in a natural world that has always been here¹⁰. It was we who, more practically, cut this gordian knot to implement research and forgot what webs were there, which knowledges, subjects, utterances, powers.

According to Marcia Moraes (2013, p. 6), translation "is not only a vocabulary change, it is a displacement" (our translation). The Actor-Network theory leads us to observe how an entity (human or nonhuman), called actor, produces effects on or over the world and the network of heterogeneous connections (elements, knowledge, partnerships, interests, and others) that connect an actor to other actors and networks (MORAES, 2013).

According to Michel Callon (2008; 2006; 1986), one of the founders of the Actor-Network theory, the translation proposal is to associate/circulate, i.e., by associating themselves or by something circulating through them, through the lead wires of this network. The author exemplifies it by the shellfishes in a French harbor. The local population, the fishermen, the gastronomy entrepreneurs, public officers, and scientists are associated. Something of mutual interest circulates through them: shellfish cultivation. This cultivation satisfies the local economy and culture, promoting the shellfish population stability, and the scientific knowledge due to a biological system of cultivation and an extractivist practice.

Bárbara Viana et al (2020) mention that the use of the Actor-Network theory permits the identification of networks, produced in the relations and associations between the most diverse actors. Thus, understanding the actors as multiple possibilities, objects, persons, animals, instruments (...), such networks are dynamic/infinite/multiple and can help us analyze a process in its whole potential: from what foments it to what interdicts it.

The versatility of Latour's thought permits the articulation of his production to different fields. However, Rezzadori e Oliveira (2011, p.19) reflect that "looking at science as a network of actors is a novelty for Brazilian theories about scientific education on schools" (our translation), i.e., it is not a common practice in scientific education, and more specifically in chemistry education.

It is amazing that Latour, being an anthropologist-philosopher-sociologist of science, whose works retell the histories of Robert Boyle, Louis Pasteur, Rudolf Diesel, and Joliot Curie, there are still few references to his work in other areas, such as administration, economy, journalism, and information systems.

Unfortunately, few people are interested in the science building process. They are intimidated by the chaotic mixture revealed by the science in action and prefer the organized contours of method and scientific rationality (REZZADORI & DE OLIVEIRA, 2011, p.19, our translation).

Some examples of this articulation between society-nature/science-politics/human-nonhumans and all other polarizations of modernity are illustrated by Latour when he explores the histories of Pasteur, Joliot, and Diesel. He shows how agencies mobilize scientists, objects, and many other elements forming a network of actors, or a sociotechnical network. Hence, through this network, we can put this "scientific fact" into circulation and oxygenate it to keep science alive (LATOUR, 1994, 1997, 2000, 2001).

The construction of the scientific fact essentially involves a delicate negotiation between scientists, who use multiple strategies of persuasive argumentation. Therefore, what defines science as a social practice of knowledge production is the interaction between actors in the local and contingent circumstances of laboratories. (KROPF; FERREIRA, 1998, p. 594, our translation).

In his emblematic book "We Have Never Been Modern", Latour narrates the clash between two great actors of science history – Boyle and Hobbes – in a word contest that shows the clash between scientific and political facts (science of nature and discourse analysis), competing for the truth and its control by means of its "purification".

Emphasizing the aforementioned natural scientists, it can be perceived that "the facts are produced and represented in the laboratory, in scientific writings; they are recognized and vouched for by the nascent community of witnesses. Scientists are scrupulous representatives of the facts" (LATOUR, 1994, p. 34). Hence, the Laboratory is a "parliament"¹² and the scientists are the spokespersons: "Boyle's descendants had defined a parliament of mutes, the laboratory, where scientists, mere intermediaries, spoke all by themselves in the name of things" (LATOUR, 1994, p. 140).

Boyle is not an isolated case. Pasteur also needed other scientists, instruments (such as the microscope), bacteria, animals, and many other human and nonhuman elements that were worked, produced, tested, modified, or that modified someone or something: here is the "agency" - here are the "actors" - here is the "network".

The actors connect with each other in a network, a network that connects animals, farmers, bacteria, microscopes, Pasteur and other scientists. This means that humans or nonhumans, which in isolation mean nothing, when connected, they permit the flowing, the resignification, the writing of new utterances and agencies (KROPF; FERREIRA, 1998).

Thus, without the experiment and its instrument, in which the scientist "inscribes" him/herself, the factors cannot be sustained. The more legitimate they are by the instruments, the stronger they will be. Thus, they will recruit more adepts, investors, partners, and many other instruments that will foster this science and its network, articulated by the scientists and their narratives. The more science is purified, more it needs translation. This is a double game that at the same time amplifies and strengthens the network. Meanwhile, Latour states that the network is the principle of nonmodernity.

SCIENCE: DEAD OR ALIVE?

A refinement in the concept of network can be made, referring to "flows, circulations, alliances, movements, instead of a fixed entity" (MORAES, 2013, p. 2, our translation), which may be useful to analyze the "displacements". "Translation operations transform political questions into questions of technique" (LATOUR, 2001, p. 117); thus, the very translation operations are translated into a five-step guide that scientific studies have to pass to keep alive as scientific facts. Some authors considered the circulatory system of scientific facts as the blood flow of science and as the vascularization of scientific facts, all synonyms and analogies for a process that makes science pulsating, i.e., alive (SILVA; LISBOA; OLIVEIRA, 2016).

Latour (2001) evidences this movement in five steps that he calls loops. The first loop consists in "mobilization of the world". Mobilize is to make something movable, i.e., to displace nonhumans (instruments or events) as a discourse for society. However, "the word 'mobilization' will mean neither instruments, equipment, nor expeditions, but surveys, the questionnaires that have gathered information about the state of a society or an economy" (LATOUR, 2001, p.119).

The second loop is called "autonomization" because it occurs when a human or nonhuman (discipline, profession, institution, etc.) "becomes independent and forms its own criteria of evaluation and relevance" (LATOUR, 2001, p. 120). Thus, investments are made on individuals training and development, making them colleagues, and on the perfecting of instruments and tools for autonomous responses and mechanisms (LATOUR, 2001; PRICINOTTO, 2012; PRICINOTTO; OLIVEIRA, 2016a, 2016b).

Once disciplines, institutions, professions, and colleagues are automatized¹¹, alliances become necessary and this is the third loop. Alliances "are what makes this blood flow¹³ much faster and with a much higher pulse rate" (ibidem, p.123).

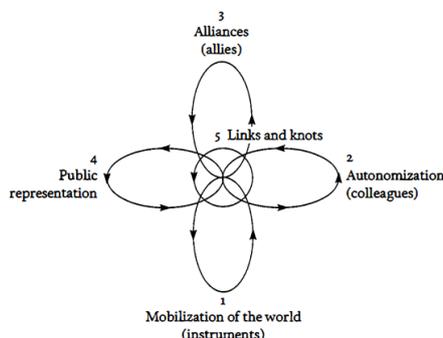
The fourth step is more tactile to our contemporary scientific community, referring to the translation/displacement's practices. When scientists develop something, a science or a technology, they need to promote a public representation of their creation¹⁴. Thinking of science public representation only as a divulgation to the community, scientific or not, is insufficient. It is this moment [public representation] that makes everything socialized – all the specter of entities (instruments, tools, professionals, colleagues, staff, government, industry, army, university, and others) is articulated for the development of science, which is socialized, modified and associated (LATOUR, 2001).

The translation of all this network to society is hard because scientists have to mediate it to heterogeneous entities with unknown epistemological formation and social representation, as well as unknown trust in science. Without this success, scientists put in danger funding and partnerships. Thus, they have to translate their creation and displace their interests, goals and intentions from the society to their science and form a system of shared believes and opinions.

The fifth step refers to "links and knots" that keep resources and other loops united. Links and knots are in the core of science as a conceptual content composing the contextual content. According to Fábio Silva et al (2016, p. 56), it is "the technical-scientific interest or the knowledge production space that

intertwines entities and their actions” (our translation); thus, it legitimates and justifies the scientist. Figure 1 summarizes these stages.

Figure 1. Vascularization of scientific facts.



Source: Latour (2001).

To be able to call science alive, scientific facts need to circulate, keeping science pulsating. Science needs to flow to technology and from technology to society. It needs to flow between laboratories, fields, engineers, scientists, the lay person and the professional.

OPENING THE BLACK BOX: WEAVING/CIRCULATING THE NETWORK

A box is open and in it we see a complex system of electronic circuits. Through its wires circulate electric impulses, data, and pieces of information. While the system works, only matters what comes in or out – input and output. The paths made by this data and the processes they suffer do not matter. We will only circulate this circuit if we want to reproduce a box or if it has a short circuit and fails.

This analogy helps us understand how a laboratory or a successful research group emerges, how this group is consolidated and makes science alive or circulates facts.

To understand this flow, we use the Actor-Network theory, which permits us to understand technoscience and its relationships with varying fields (economic, political, social, environmental, natural, and scientific). This theory guides us to the different entities and the importance of each link that builds this network. Human and nonhuman entities are actors and articulate between them, arranging themselves through practices and mainly process of translation/displacement.

The application of Bruno Latour's perspective in Brazilian research reality, using as case of analysis a Chemistry Institute (IQSul) in the south of Brazil, motivated this article and its divulgation in a scientific journal. We understand that scientific circulation when well understood may explain some impasses/obstacles to its condition of being dead or alive.

An alive science with circulating flows promotes the quality of scientific facts that impact and transform society. A dead science feeds and spends resources producing a minimum of scientific facts that feeds only a microcosmos without the potency of massively displace, create new flows, or cause an impact on society.

Thus, it is essential to know the flows of a science and make its practices more dynamic, particularly, in countries whose social well-being is not yet guaranteed for all, such as in Brazil.

Regarding data collection, initially we contact researchers/scientists that work in the laboratories of IQSul, who are, in the academic environment, professors, managers, research group leaders. The institute has 98 professors, researchers, scientists, and insitutionalized18 research laboratories of the different fields of chemistry, including chemistry education.

The study started with 21 interviewees, catalogued with mineral code names. Chart 1 presents the code name and year in which they started teaching, which is not restrict to their beginning in the institution as some professors started working on other institutions or universities. The choice of the professors was due to their availability and closeness to the authors of this study, who tried to transit between the different laboratories.

Chart 1 – Code names and teaching career's initial year.

	Code name	Year		Code name	Year		Code name	Year
1	Crocidolite ¹⁵	-	8	Dolomite	2013	15	Malachite	2007
2	Amazonite	2017	9	Fluorite	1997	16	Marcasite	1988
3	Aragonite	1991	10	Hematite	1990	17	Pyrite	2000
4	Azurite	1990	11	Labradorite	2002	18	Rhodochrosite	2014
5	Bornite	2014	12	Lazurite	1980	19	Rhodonite	2006
6	Cobaltite	2010	13	Leucite	2013	20	Sodalite	2003
7	Cuprite	1986	14	Magnetite	2009	21	Uranite	1980

Source: The authors (2020).

Initially, this study used as data collection tools the application of an online questionnaire sent through e-mail and a Google Forms questionnaire, both with the same content. The heading described the nature of the research and asked for interviewees' consent. They were also informed about the anonymity of the research. After discursive analyses, we perceived the need to amplify the questions with some interviewees whose data lacked clarification.

The questionnaire primarily aimed to understand how the professor/researcher/scientist was interpellated and mobilized for a given line of research, whether by recruitment, attraction, translation, or displacement to the scientific community (IQSul) or by some other paths this network can reach.

Our analysis went beyond the factors, the references, and the experiences that were considered representative for professor-researcher's training and maintenance, approaching how they became a reference and how they mobilize undergraduate students through their narratives. Thus, we trace some flows of science in action.

Hence, the first webs of training in these networks start to acquire form when they enter into the field of science and by the paths through which the actors reach it. This analysis is not finished in the surfaces and dimensions that will be presented. Further studies mapping the agency are required. However, we delimitate the inputs of the subjects (professors/researchers/scientists) and their training based on a construct made while studying the questionnaires and their answers. They evidence that family or intersubjective relationships with high school teachers were determinant for the insertion in the field.

After joining the academic environment, our look turns to the researcher profile as, in Brazil, this is one attribution of the subjects-professors due to the triad teaching-research-outreach. The inseparability of this axis should guarantee the technological, scientific, and social development, which feeds back the professional training with the investments of the public and private sectors, the elaboration and execution of research projects that make it a prototype for industry and society, and the elements and devices to scientific progress and development offered by the university.

We defined six groups in which subject-professors were categorized according to the motives they entered in their lines of research. The categories brought in decreasing order of occurrence are: (i) application of the knowledge acquired during the undergraduate course, as a continuation of the works developed during the undergraduate or graduate research (7); (ii) the challenge and the synthesis of new materials (4); (iii) wonder, curiosity, and the "investigative spirit" (3); (iv) feeling of social and environmental responsibility (2); and (v) development of research in areas not explored during the undergraduate course or with "lack of investigation" (2).

Such diverse motivations present the modus operandi of scientists because it is the driving force to develop research. With this bias, the displacements for scientists can occur by the eagerness for conceptual scientific knowledge, either mobilized by the undergraduate or graduate course or by the need to understand something that was not explored enough in these moments and space, which is seen by the occurrence and proximity between the categories i and v. Motivations converge as the category ii is close to iii. Challenge, curiosity, and the "investigative spirit" are feelings that cross each other, as well as the wonder while developing new materials or producing scientific facts.

These subjects' new inputs to weave this sociotechnical web must permeate the very field of scientific knowledge, science itself. This occur because they seek research as a way to apply, understand, and modify the world around them, and the world itself mobilizes them, reinforcing the proposal of social and environmental responsibility.

Thus, we understand that the answers of professors-researchers-scientists about their insertion and action in the field, and the recruitment and translations to their lines of research, are of varying natures. It includes the influence of professors (as something hereditary) and the reception they had during the undergraduate course (specifically during undergraduate research) or graduation, or by the very "scientific spirit".

Within Latour's proposal about science's blood flow, in this moment of the network, subjects-professors-researchers-scientists make clear that they passed

through the first and second loop, mobilization and autonomization. By being a part of community, they are autonomized, they are colleagues, standardized and recruited as previous professors used convincement and recruitment tools in their research groups (recruitment), fostering the "scientific spirit" (mobilization), the curiosity, and the challenges to build techniques, technologies, and science.

It is essential to perceive that when they were asked to explain their beginnings in the field, researchers/professors present and justify their researches and laboratory activities within a discourse disseminated and revitalized in the scientific field, which is for the development and social well-being. The "links and knots" already present their first "tackings" with technoscience. Nevertheless, during their researches, what is perceived is an aseptic analysis centered on the laboratory and the academic universe with little or no social perspective.

The new professor-researcher-scientist, although under the shadow of the predecessors, must walk with his "own legs" and make alliances and recruitments, as proposed in the science blood flow theory. Among the innumerable possibilities these professional alliances can assume, we evidence the alliances build by professors-researchers-scientists based on the action of recruitment.

Recruitment is understood as the captivation of students in the same manner that many of these subjects were also recruited through classroom experiences and undergraduate research opportunities. Thereby, we turn our look to some spaces where the scientific knowledge is produced: the classroom and the chemistry laboratory. In this context, the professor-researcher-scientist have to translate his research and knowledges, translating them to students.

Recruitments, as seen before, demand a work of translation of their researches for the classrooms because the professor-researcher-scientist acts as the main divulgator during the teaching narratives. In the data survey, we sought to identify the translation, questioning if the research subjects can relate the laboratory work with classrooms contents/concepts¹⁶.

Four (4) professors mentioned that rarely or never work in the undergraduate course with their lines of research. However, in this group, two professors gave classes contemplating their researches in graduation disciplines. In these cases, there is not an immediate recruitment because students already pertain to a research group. Nevertheless, it is always possible to consider an interest for the next steps of the career. The third and the fourth professors could not work their lines of research with the undergraduate course because they teach basic disciplines without direct relation with their lines. However, the fourth professor eventually uses his personal knowledge to bring contextualized examples.

Besides those two interviewees that did not contextualize their lines of research in classroom, there is another professor that, although working in the undergraduate course with his line of research, opted to not approach it. Contrariwise, the professor understands the importance of students' knowledge and experiences, relating them to the topics of the discipline. In a second interview, the same professor clarifies the avoidance of talking about his researches due to the "vanity" of his former professors. When talking about their graduation or post-doctorate experience, in his view, they prejudicated and hardened the work and study. The speeches of this professor are in chart 2.

Chart 2 – Excerpts of Labradorite's interview

Question	Speech
9	"I speak the least possible about my research in class (when it serves as an example to the topic) and not contrariwise. When I was a student, I hated professors who used the class to speak about themselves and their research. Maybe it limits a little. I prefer to look as if what I approach can help the work of someone."
Second meeting	"For me, the aim of speaking about my research is to open students' eyes to what have been done with that knowledge (many times, at a first glance, it is arid), and very briefly about what has been done around them (if a student likes it, he goes after it)."

Source: The authors (2020).

Fifteen (15) interviewees correlated their lines of research with the undergraduate disciplines, contextualizing, and exemplifying. We highlight the speeches of some professors in Chart 3.

Chart 3 – Excerpts of the interviews for the question 9.

Interviewee	Speech
Marcasite	"More recently I started to introduce in theoretical classes real examples of things we can present to students and develop in them a higher 'taste' for Chemistry."
Fluorite	"[...] moreover, my practical class is in my research laboratory, using catalyzers of ongoing projects."
Lazurite	"[...] it is a constant exchange: the theoretical knowledge developed in class helps me interpret my research results, and my research is a source for examples in class."
Hematite	"[...] there are many examples of research and outreach activities performed that contribute to the teaching practices."
Amazonite	"[...] I choose to give classes for Pharmaceutics' students as my research area is close to them."
Magnetite	"Anyway, basically all disciplines can be exemplified with research activities I already developed."

Source: The authors.

In the last analysis, it is perceivable the difficulty that some lines of research have in recruiting students in the classroom. It may occur by a difficult connection with basic disciplines, by negative experiences, and consequently by some departments too (Organic Chemistry Department, Inorganic Chemistry Department, Physics-Chemistry Department).

Two interviews from the same department corroborate this perception. However, the very department articulated itself in this year, elaborating a project

in which professors organize seminars to present their lines of research, making possible student recruitment. Here we can perceive a "seduction" game more focused on the necessity of constituting equals in competence as a mean of survival for their research field than on promoting the will to knowledge.

We differentiate the translation practices of translation itself (alphabetizing students to comprehend and build this knowledge) and displacement (mobilizing/recruiting students so that their interests converge with the interests/goals of professors-researchers). Translation and displacement may be considered synonyms and are so by the Actor-Network theory (Sociology of Translation). However, in the case of IQSul, we opted to differentiate them because the processes are effectively different: translation implies the promotion of knowledge and displacement implies the agency to promote the pairs. Translation, in a wide sense, is responsible for both actions, which can be perceived in some teaching practices.

Another professor of other department, grouped among the four professors that cannot align their line of research with undergraduate disciplines, in an informal conversation, comments about the necessity of divulging his work, which he does outside the class for a wider public, including elaborating a website for the laboratory.

It is explicit in the research documents that the "vascularization of scientific fact" has its clots in this process of teaching action because it blocks the blood flow, generating a pathology. Thus, the public (re)presentation of science within IQSul occurs through scientific divulgation in specialized journals and eventually in academic databases. Therefore, they attract-capture-enlist-displace-recruit students through convincement and divulgation, although it is not a homogeneous practice.

It is also evident that laboratories and professors-researchers-scientists do not even know each other. They reported unfamiliarity with their pairs' researches and complained about the lack (or insufficient) divulgation of the work of the institute's professors to other members of the community: technicians and other workers.

According to Massi & Queiroz:

The difficulty to relate teaching and research in the undergraduate course goes back to the fact that some professors establish a difference between the classroom and the research environment. Hence, the undergraduate course remains a space of reproduction and not production of knowledge, while the research environment is much more valued and alters the behavior of professors in the elaboration of routines, relationship with students, and investments (MASSI & QUEIROZ, 2010, p. 179, our translation).

Therefore, when starting in academia as professors, the subjects-professors/researchers-scientists tend to reproduce their experiences. However, it apparently occurs in less traditionalist terms. It is presented by the study of Daitx, Loguercio & Strack (2016) as a vicious circle: the scientific research conducted in IQSul still has no place in teaching practices, affecting the "science blood flow" of alliances with humans originated from the same "house".

CLOSING THE BOX

This study revealed itself as a fruitful space for the proliferation of knowledge established in modern terms, in the sense that the standardizing can be defined by an alleged critical rationality aimed by modernity. Constituted by modern discourses, the subjects-professors-researchers (re)produce practices that normalize and recruit students to be "normal chemists", to form a collective that legitimates their practices.

However, the non-observance of translation/displacement within the undergraduate period leads to conflicts related to the tying of knots because it fails in the recruitments, agencies, alliance formation, and the "public representation" (divulgation) within the very institute. This fact occurs within the Latour's perspective about the "vascularization of science", the "links and knot", the final stage of the circuit where all the previous actors and loops are tied. Here we perceive the clots in this vascularization, where these imbroglios lead to low frequency of adherents to some departments and research groups and low number of sub-collectives – if we think in the institute as a larger collective.

This fact reflects in the syllabus and the teaching and evaluation methodologies. According to the professors' speeches, the most significant moments were not in the undergraduate teaching but on the moments they were autonomous, working in laboratories, undergraduate and graduate research. Thus, they left teaching practices in a universe with an agonizing chemistry in classrooms.

In other words, as we argued following Latour, science must come to action, imbricating lines of translation, hybridization, and recruitment into a fluid process in which humans and non-humans occupy spaces in the knowledge networks. Nevertheless, a fail in one or many factors ends up producing alienation and dissatisfaction, becoming incapable of creating new propositions in the scientific field, hardening the networks.

We may think that IQSul has its networks minimized or stagnated because some researches developed do not reach academic databases, neither are widened to the social field or the scientific knowledge divulgation. They do not approach the cutting-edge researches conducted in the same institution, and some areas (disciplines) are basic, which leads us to a "dead science". As Latour proposes, a trend of the "networks", when they do not fulfill their roles, is to end up splitting the sciences into the groups "facts, power, and discourse".

Thus, the professors' speeches make evident that it is within the chemistry laboratory that everything occurs. Opportunities, such as the undergraduate research, are what permits students to access the cutting-edge techniques and technologies in order to be a part of the collective that makes science.

Many times, the choice of the laboratory and the scientific trajectory is not defined by affection criteria, i.e., by the translation of interests that emerged in the undergraduate course, but by scholarship and research opportunities. Groups with few scholarships have less agency; hence, science and researchers are minimized by an economy more related with investments than knowledge.

Thereby, the chemistry laboratory is fundamental for the epistemological development of students and their constitution as subjects-professionals (subjects-scientists). However, beyond what we commonly imagine, it is in the

laboratory where we can observe practices of mediation, translation, public representation, alliance, mobilization, normalization, and recruitment.

Students become limited by experiencing only one space, one context, one ethos (a common characteristic of a group of individuals within the same society) within the laboratory. Limiting individuals' development is minimizing not only their knowledge network but their acting network. Thus, chemistry laboratories, although becoming black boxes as their processes are automated, are also responsible by the black box that covers the development of individuals' scientific identity.

It is curious that a line of research, highly regarded and known, is not seen in classrooms but still recruit students at the point of becoming more than a laboratory, a collective. Somehow, these actors' network mobilizes other actors and networks. Then, the laboratory ends up being the product of different agencies, objectives, and displacements. However, thinking of lines of research as actors with no agency in class is a failure for scientific knowledge construction. It corroborates other studies that show that the current society is not concerned with knowledge production.

Studying a space through the Actor-Network theory helps mapping or making an ethnography of the space. It permits the tracing and comprehension of the links, multiple flows, and displacements caused by academic environments, classrooms, and chemistry laboratories, as they are constituted by non-declared actors, unknown flows and vascularization that open these black boxes.

Finally, we perceive in the interviews that (a) most professors were not interpellated in classroom during their undergraduate studies. This fact denounces a rigid and archaic system of class with a traditionalism that impedes autonomy and hypothesis elaboration. However, the (b) moments in which students were in the laboratory, whether on undergraduate or graduate research, acting (in)directly in experimentation and research, make them more active within the profession. Then, (c) this is the moment that knowledge production is promoted; hence, (d) it establishes the relationships between the beings to build a community and a collective.

Considering that the scientist does not work alone, and that science is not built alone, to be kept alive, science must circulate (translate), in the literal sense of the word, from the class to the laboratory, and from the laboratory to the class. We observed that it is the (e) obstruction of the last path that marginalizes an academic area and stagnates it.

When interpellated by the axis teaching-research-outreach and through innumerable attributions, the interviewees (f) do not denounce the teaching practice as memorable, since they did not mention having a teaching habilitation, and those who had it did not mention the habilitation as remarkable.

The disconnection of the university triad in practical terms denounces that some professors make the distinction, intentional or not, between the classroom and the laboratory. Teaching is seen as a burden, which reflects in the few mentions to the teaching practice.

The evidence found in this study suggests that the practices (and their doers) within the undergraduate course must be reviewed. Obscuring and hardening the

disciplines as they were conceived conducts to science clots. However, it makes clear that the chemistry laboratory is a network of actors, students-professors-scientists-spokespersons-objects, hybrids in a network desiring to make science.

Is it dead or alive? The answer remains paradoxical as it is impossible to predict without opening the "box". Some lines of research emerge and others submerge, independently of the classroom. However, they are alive in the laboratories, supported by a scientific community that grows and reinforces itself externally.

A tradução do curso de química: uma ciência viva ou morta?

ABSTRACT

O conhecimento científico é construído em uma comunidade científica e, no Brasil, essa está concentrada nas universidades. É nesse ambiente que diversas relações permeiam, atravessam e dobram os seus sujeitos, subjetivados por agenciamentos e por práticas discursivas e normalizadoras. Analisar como tais comunidades se formam e ampliam seus territórios é, ao mesmo tempo, observar como elas se mantêm viva. Uma das estratégias que nos permite olhar para isso é acompanhar os Fatos Científicos que circulam e oxigenam tais comunidades. Seguir pelo campo da química nos conduz a analisar as salas de aula, os laboratórios químicos e de pesquisa, os discentes e os docentes, atores humanos e não-humanos. Nossa pesquisa foi realizada por meio da análise de discurso de entrevistas com docentes universitários do curso de Química. Assim, o que encontramos foi uma “caixa-preta” cheia de emaranhados mecanismos que garantiriam o sucesso. Nesse sentido, o uso da Teoria Ator-Rede nos auxilia a compreender esses fluxos e assim diagnosticar uma ciência viva ou morta, que somente saberemos ao abrir tal caixa.

KEYWORDS: Laboratório. Teoria Ator-Rede. Química. Fatos científicos. Latour.

NOTAS

1 A fourth axis is discussed, university management/administration, as in Public Universities this role is performed by technical employees or professors and not by external members.

2 The main figures of the 17th and 18th centuries, such as Boyle and Lavoisier, developed their researches in personal laboratories because Chemistry was not a discipline of pure science. It was used in universities as a resource to be applied in other areas, such as medicine and mineralogy, and was conducted by Medicine or Pharmaceutics' professors. (Maar, 2004).

3 The Royal Society of London was founded in 1660, and Robert Boyle was one of its founding members. With the aim of spreading and promoting scientific knowledge, it was one of the first scientific societies and institutions. In 1666, the Académie des Sciences (Academy of Sciences) was created in France, a French equivalent for the British society.

4 The work "Laboratory Life" (LATOURE; WOOLGAR, 1997) is a building block for the social studies of science because this ethnography of the scientific practice, made in the laboratory, evidenced science as a social practice and the scientist as a social actor. The book also shows how science production and sustenance occur, the disputes and legitimization of/by utterances and scientific facts. Hence, this book permitted the emergence of other studies with the same perspective.

5 An approach about the technoscience presented in the book "Science in the transition of centuries: concepts, practices, and historicity". (FREIRE JUNIOR; GRECA; EL-HANI, 2014, our translation).

6 French theorist of science, considered a hybrid (anthropologist-sociologist-philosopher) in this study. Doctor of Philosophy, he acts as a professor and collaborates with many social studies of science in many parts of the world.

7 Here is the rupture of a system, modernity within science. This is a discussion conducted in Bruno Latour's book "We Have Never Been Modern" (1994).

8 We use the following English translation: LATOUR, Bruno. We Have Never Been Modern. Translated by Catherine Porter. Cambridge: Harvard University Press, 1993. This citation appears on p. 11 of this edition.

9 The Gordian Knot refers to a metaphor about a knot that no one could untie, representing insoluble problems. The peasant Gordias untied the knot, cutting it. Hence, he made it in a simple manner, showing that simple solutions can resolve complex problems but it is necessary to think "outside the box".

10 Our emphasis.

11 Parliament is an assembly gathering elected members, called parliamentarians, to represent citizens. With this expression, Latour sagaciously unites what Boyle and Hobbes tried to separate: politics and science.

12 Professionals of several areas, especially scientists and engineers, converge to the same goal.

13 Our emphasis.

14 We adopt the analogy of scientists as creators and their works, scientific or technological, as creatures, following Rezzadori & De Oliveira (2018).

15 The professor Crocidolite did not inform the time nor the year he started teaching, only citing that he started when "21 years old".

16 Of the interviewees, only one did not answer the questionnaire.

17 Text translated by Camila Faustino de Brito. Contact: camila.brito@ufrgs.br

REFERÊNCIAS

CALLON, Michel. Entrevista com Michel Callon: dos estudos de laboratório aos estudos de coletivos heterogêneos, passando pelos gerenciamentos econômicos. *Sociologias*, n. 19, p. 302-321, 2008.

CALLON, Michel. Sociologie de l'acteur réseau. *Sociologie de la traduction. Textes fondateurs*, p. 267-276, 2006.

CALLON, Michel. Eléments pour une sociologie de la traduction: la domestication des coquilles Saint-Jacques et des marins-pêcheurs dans la baie de Saint-Brieuc. *L'anné Sociologique*, n. 36, p. 169-208, 1986.

CASTELFRANCHI, Juri. As serpentes e o bastão: tecnociência, neoliberalismo e inexorabilidade. Tese de Doutorado (Doutorado em Sociologia). Universidade Estadual de Campinas, Campinas, 2008.

DAITX, André Cristo; LOGUERCIO, Rochele de Quadros; STRACK, Ricardo. Evasão e retenção escolar no curso de licenciatura em química do Instituto de Química da UFRGS. *Investigações em Ensino de Ciências*, v. 21, n. 2, p. 153-178, 2016.

DE OLIVEIRA, Moisés Alves. Os laboratórios de química no ensino médio: um olhar na perspectiva dos estudos culturais da ciência. Scielo-EDUEL, 2009.

FOUCAULT, Michel. A ordem do discurso: Aula inaugural no Collège de France, pronunciada em 2 de dezembro de 1970. 12ª ed. (Publicação original em 1971). São Paulo: Loyola. 2005.

FREIRE JUNIOR, Olival; GRECA, Ileana María Rosa; EL-HANI, Charbel Niño. Ciências na transição dos séculos: conceitos, práticas e historicidade. Salvador: EDUFBA. 2014.

KROPF, Simone Petraglia; FERREIRA, Luiz Otávio. A prática da ciência: uma etnografia no laboratório. *História, Ciências, Saúde—Manguinhos*, v. 3, n. 5, p. 589-597, 1998.

LATOUR, Bruno. Ciência em ação: como seguir cientistas e engenheiros sociedade afora. (Trad. Ivone C. Benedetti). (Obra original publicada em 1999). Unesp, 2000.

LATOUR, Bruno. A esperança de pandora: ensaios sobre a realidade dos estudos científicos. (Tradução de GCC de Sousa). (Obra original publicada em 1999). Bauru-SP: EDUSC, 2001.

LATOURE, Bruno. *Jamais fomos modernos: ensaio de antropologia simétrica*. (Trad. Carlos Irineu da Costa). 2ª ed. (Obra original publicada em 1991). São Paulo-SP: Editora 34, 1994.

LATOURE, Bruno. *Reagregando o social: Uma introdução à Teoria Ator-Rede*. (Trad. Gilson Souza). (Obra original publicada em 2005). Salvador, Ba: EDUFBA, 2012.

LATOURE, Bruno; WOOLGAR, Steve. **A vida de laboratório**: a produção dos fatos científicos. (Trad. Andela Vianna). (Obra original publicada em 1979). Rio de Janeiro: Relume Dumará, 1997.

MAAR, Juergen Heinrich. Aspectos históricos do ensino superior de química. *Scientiae Studia*, v. 2, n. 1, p. 33-84, 2004.

MORAES, Márcia. A ciência como rede de atores: ressonâncias filosóficas. *Revista ATOR-REDE*, n. 1, 2013.

PRICINOTTO, Gustavo. *A arregimentação de aliados e a produção de químicos*. 2012. Dissertação (Mestrado em Ensino de Ciências e Educação Matemática) – Centro de Ciências Exatas, Universidade Estadual de Londrina, Londrina, 2012.

PRICINOTTO, Gustavo; OLIVEIRA, Moises de Alves. O riso que desordena a ideia purificada do ser professor de Química. XVIII Encontro Nacional de Ensino de Química (XVIII ENEQ). Anais. Florianópolis, SC, Brasil. 2016a.

PRICINOTTO, Gustavo; OLIVEIRA, Moises de Alves. Ser um bom Químico: A arregimentação que forma sujeitos “Normais”. XVIII Encontro Nacional de Ensino de Química (XVIII ENEQ). Anais. Florianópolis, SC, Brasil. 2016b.

REZZADORI, Cristiane Beatriz Dal Bosco; DE OLIVEIRA, Moisés Alves. Educação química e pensamento latouriano: uma possível articulação. *ACTIO: Docência em Ciências*, v. 3, n. 1, p. 224-247, 2018.

REZZADORI, Cristiane Beatriz Dal Bosco; DE OLIVEIRA, Moisés Alves. Educação química pelo olhar de rede latouriano. In: V Simpósio Nacional de Ensino de Ciência e Tecnologia – SINTEC, 2016, Ponta Grossa. Anais 2016. Ponta Grossa: Editora da UEPG, v.1. 2016

REZZADORI, Cristiane Beatriz Dal Bosco; DE OLIVEIRA, Moisés Alves. A rede sociotécnica de um laboratório de Química do Ensino médio (The sociotechnical network of a high school chemistry laboratory). *Experiências em Ensino de Ciências* – V6(3), pp. 16-37, 2011.

SILVA, Fábio A. R.; LISBOA, Débora P.; OLIVEIRA, Denise P. L. Teoria ator-rede, literatura e educação em ciências: uma proposta de materialização da rede sociotécnica em sala de aula. *Ensaio Pesquisa em Educação em Ciências*. v. 18, p. 47-64, 2016.

VIANA, B. M. M.; SILVA, S. E. M.; PRAÇA, P. V. L.; TAVARES, J. C.; SILVA, F. R.; COUTINHO, F. A. A pandemia da COVID-19 como uma questão sociotécnica para a educação científica. *ACTIO: Docência em Ciências*, Curitiba, v. 6, n. 2, p. 1-22, mai./ago. 2021.

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