HISTORY OF SCIENCE AND ENVIRONMENTAL EDUCATION IN THE *EXPEDITION ALONG THE IPIRANGA STREAM*

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Introduction

Despite the growing education research using local and regional approaches to discuss science (COMPIANI, 2007), there is still great relevance in proposing new reflections on scientific practices developed in Brazil and thinking about the relationship between history of science and environmental education from a contextualized view, as opposed to the universalist and hegemonic approaches that are still strongly present in science teaching. We follow here the concise view of Margaret Lopes (2005), who defends that natural history, as well as the science branches stemming from it, has historically consisted of building local practices for creating collections and global inventories. Accordingly, the history of science becomes an essential instrument for us to epistemologically understand the theories and practices in areas, such as biology and geosciences, to build teaching methodologies based on studies conducted at the studied place.

By emphasizing the approach that values the local environment and science, associated with developing global practices, we propose here to present some reflections on the relationship within a fieldwork used in teaching, from the history of science view. The activity in question, named "*Expedition along the Ipiranga stream*," was performed in the city of São Paulo and covered two scientific institutions: The Jardim Botânico de São Paulo (JBSP) *[Botanical Garden of São Paulo]* and the green areas from the old arboretum of the Museu Paulista (MP) *[São Paulo Museum]*, by using the Ipiranga stream as outline for studying the urban micro-basin, following the trajectory shown in figure 1, with emphasis on the Expedition's main stops.

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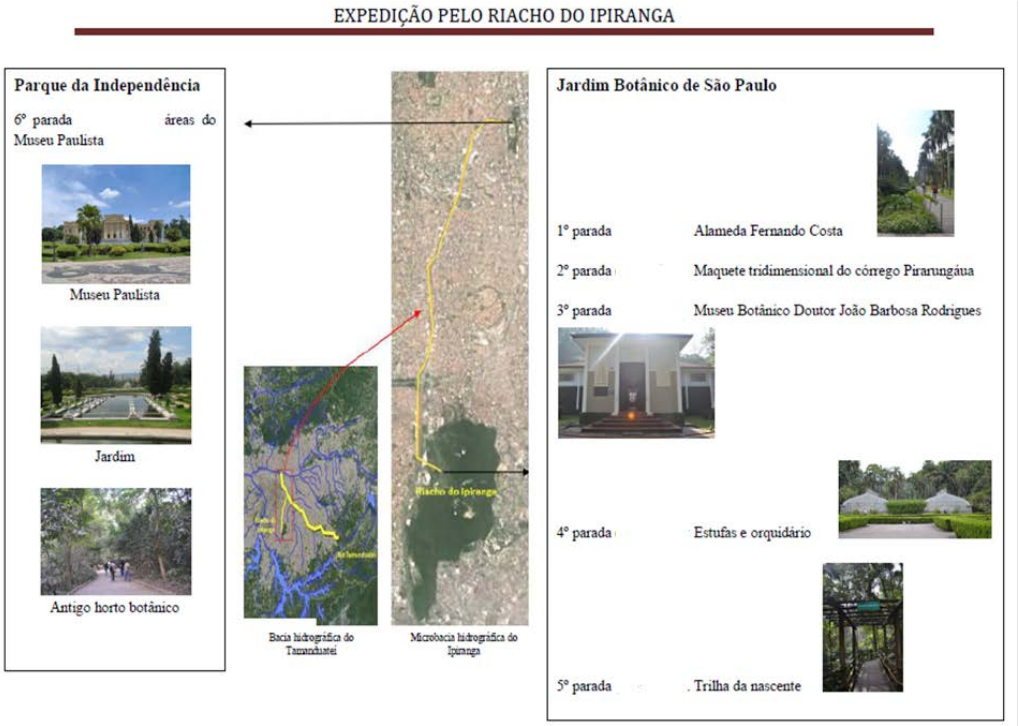
Figure 1: Expedition trajectory following the Ipiranga stream. In: Bandeira (2015)



We created the Expedition as an education process that was built by means of research and was subjected to constant reviews, directly referring to the critical education concepts of Paulo Freire (1987). Such process leads visitors to continuously dialogue with their peers, so that they recreate themselves in their practices and with the world and become inquiring and unsettling. It is open to new possibilities and there is always room for new views to be discovered. This characteristic fully matches the activity's very name, since expedition is understood as the act of researching, studying, exploring and unravelling, as defined by the Houaiss dictionary (2001).

The education proposition underwent constant reflections involving several researchers in the creation of extension, undergraduate and post-graduate courses, as well as didactic material production and scientific dissemination. It was first produced to integrate the education project called "Este Mundo é Meu!" *[This World is Mine]*, developed at the Centro Cultural São Paulo (CCSP) *[São Paulo Cultural Center]* in 2008, with the purpose of raising awareness toward the issue regarding water resources located inside a large city and engaging the participants in a non-formal education practice by historically recovering the Ipiranga stream. In 2009, the fieldwork took part in the 2nd Teaching and History of Earth Sciences Symposium, when a visitation guide was prepared and expanded history research on scientific institutions, practices and performances of the institutions' main founders (PATACA, SILVA; 2009).

We highlight in this article the incorporation of the practice to the History of Science classes included in the Graduate program taught at the School of Education at USP in Brazil, in 2010. From there, the Expedition underwent concept and methodology development, which involved a vast number of subject-related themes that were addressed and discussed during the trajectory and were enriched with the bibliography about science in Brazil, adopted by the graduate course, from the colonial days to the First Republic. The results of this activity, which were collected via participant's observation, document analysis and questionnaires answered by post-graduate students, were analyzed by Camila Bandeira (2015) in her master's degree dissertation and are partially systematized in this article[3].

The practice has been already applied to the initial and continuing teacher training program. In 2011, it was one of the propositions for the Science Teaching Specialization course for Elementary School teachers from the Municipal School System in São Bernardo do Campo, and, in 2014, was included in the Geoscience and Environmental Education Teaching Methodology (LIGEA-USP) subject. In both contexts, fieldwork methodologies and association with the use of images, scientific collections and instruments were vastly explored, in addition to discussions with teachers, both professional and in training, about environmental perceptions in the diversity in landscape and environments explored throughout the trajectory.

Between 2013 and 2014, the Expedition was the base material for developing a University extension project for creating scientific dissemination material, which was the result of a partnership established between Hugo Segawa, from Faculdade de Arquitetura e Urbanismo *[School of Architecture and Urbanism]* at USP, his undergraduate students, Bruna Dallaverde de Sousa (FAU- USP) and Vanessa Domingos Duarte (ECA-USP), along with the authors of this article. A first fascicle about "Water Resources" was created and contained explanations about the river basin and the urban changes that took place since the MP was first built.

The Expedition's education and investigation development process reveals the inseparability between teaching, research and university extension by integrating formal and non-formal teaching environments. This meaning is grounded on the idea that social education practices must abstain from the mechanical action and turn to contributions that are distinct from and dependent on the circumstances (GÓMEZ, 1992). Accordingly, for every practice, despite following the same guidelines, the student's previous knowledge, the guiding issues, the Expedition's goals, the phenomena, the contents, the strategies to raise the awareness of those involved and the post-fieldwork systematization process are taken into account. The Expedition is developed with the collaboration of different agents, by incorporating their ideas, concepts and views in the fieldwork, and by building new possibilities that are expressed in collective discussions.

Since we start from an activity under reconstruction, we propose in this article to highlight some of the Expedition's aspects, aiming at understanding and promoting reflections on the education proposition with historical relevance, while highlighting

3. It is not applicable here to delve into the specific application of this intervention.

the possibilities of on-site environmental and scientific investigation. With this problematizations, we intend to cooperate with educators of formal and non-formal education institutions in developing historical and educational Expeditions. We will present the theoretical and methodological approaches, grounded on Environmental Education and History of Science references, by exposing the fieldwork methodologies that were built by studying scientific practices, systematized and spread by the complex social relationships that are centered in scientific institutions, such as museums and botanical gardens.

The historical approach that was mobilized during the expedition, while valuing the science branches produced in Brazil, also approaches the scientific practice and identifies it by the epistemology, methodology and ideology from its own time and space, with scientific representations, practices, documents and institutions that were conditioned by economic, social, political and environmental factors.

Links between History of Science and Environmental Education

Science gives meaning to how we relate to Nature. However, in most education propositions, they are strongly linked to a view that is detached from social issues. To counter this ideal and avoid a present-formatted science – whose purposes back up the formation of uncritical individuals that are detached from the reality (PEREIRA E SILVA, 2009) –, what is necessary is that "*the teaching of sciences must simultaneously be within and about science*" (MATTHEWS, 1995, p. 166). In other words, education practices should not be restricted to the scientific method and the procedures involving it, such as the meaning of the Atlantic Forest biome or what a water basin represents, among many other isolated and fragmented concepts within science. Thus, in order to build reflections with substance that are able to develop new attitudes and views toward the dynamics of the environment, what is necessary is to overcome a merely content-based approach to science, by admitting its critical nature, and socially contextualizing it. This "*about science*" expression to which the author refers is intrinsically linked to that process the science activity undergoes, the context it is inserted in, the factors that permeate and influence it in building a certain concept or theory, as well as its distinct interfaces, such as observation and experimentation processes.

Based on that, the didactic proposition behind the Expedition is grounded on the idea that fieldwork is one of the decisive practices for making educators aware of environmental issues. The field makes it possible to expand the school view about the reality. This allows us to promote a pedagogical experience that is challenging, creates conflict and can even shock us. Fieldwork adds to teaching training and provides new readings of and approaches to the environment, to the extent that it encourages teachers to work in interdisciplinary groups and prepare new knowledge.

Some teaching and research practices have already been built with the purpose of supporting teachers in their didactic activities. Accordingly, we highlight the creation of the Laboratory of History and Environment at UNESP in Assis, which gathers images and texts recovered by travelling naturalists and makes them available to prepare education propositions about environmental history (MARTINEZ, 2004). In turn, the development

of the researching view of undergraduate students from the Geosciences and Environmental Education at USP pervades their autonomous fieldwork, which is thought out as teaching proposition agents, and involves investigating history, geoscience and the environment in the Metropolitan Region of São Paulo (PATACA, 2015).

Fieldwork also helps to raise the awareness of those involved, since it is possible to bring what is local and what is global together, value the space's historical process and alert us about social aspects. Accordingly, Vivian Newerla (2000), analyzed the routes of the Geographic and Geological Commission in São Paulo described in the reports, photographs and maps obtained from expeditions carried out along the Feio, Fish and Tietê rivers, and provided data for comparing the landscape changes that have taken place since the early 20th Century until today. The research supported the understanding about the role science plays, from its theoretical dimension to products, in the interaction between man and Nature, fostered by studying the development of science and technology on site (SILVA, et. alli, 2008).

The extension course named Caminhos do Mar: História, Memória e Ambiente *[Sea Paths: History, Memory and Environment]*, prepared by UFABC in partnership with UNIFESP, has been taught since 2016 and consists of theoretical classes and fieldwork practices conducted in the Serra do Mar mountain range and Santos region, in order to understand the location's social-technical and environmental history. The course taught has resulted in the production of scientific dissemination material, such as e-books about fieldwork practices, audios and videos recorded by colaborating teachers and students (https://cursocaminhosdomar.wixsite.com/curso).

As the starting point for discussing contents and triggering feelings of oddness, fieldwork practices lead us to examine the daily life and perceive it in a way that is different from that which we usually do (GUIMARÃES, 1999). As an example, we mention the history problematization in building Nature concepts, which were developed and analyzed by Irineu Tamaio (2002) in an environmental education experiment conducted in Primary and Secondary Education schools, and included fieldwork conducted at Horto Florestal *[Arboretum]* and Cantagalo slums in São Paulo.

Silvia Figueirôa (2009) defends that the history of science, when introduced in the professional training of geoscientists, may lead to methodological innovations in education practices (such as fieldwork practices) and also helps to understand the historically contextualized conceptual changes. Accordingly, Lúcia Fantinel (2010) describes and analyzes the teaching of geological mapping provided at the Eschwege Geology Center (Diamantina/MG) between the 1970s and 2000s, by approaching the intellectual, social and economic history to identify the influence of models in the geology of Serra do Espinhaço mountain range. By recognizing the role fieldwork plays in the history of research and on-site teaching activities supports the preparation of history practices in training geologists.

The Expedition Along the Ipiranga Stream was prepared with its roots in the idea that fieldwork is a rich direction to follow in order to expand the meaning of education and look for methodologies that contemplate the place, the environment and Nature, in addition to the fragmented and subject contents. This understanding is based on Morin's

(2000) idea, who teaches us that to get to know the world is an intellectual need, but, even more so, a vital need for us humans. According to this thought and the proposition of discussing the relationship between man and Nature – which is often understood through the *untouched Nature myth* (DIEGUES, 2001); in other words, Nature is thought out as detached from human interactions in a contemplation or use state, without considering its historical and biological complexity – this teaching strategy is an ally in fostering a critical teaching view.

The proposition of critical teaching is present in the Expedition based on Freire's (1974) concepts, who states that there is nothing more limiting than education that does not allow the individual to dive into experiences that are surrounded by debates and analyses, in addition to the need of an education that supports understanding the relationship humans have with the world, thus allowing them to gradually, critically and responsibly intervene in their own reality. Critical Environmental education, as based on Paulo Freire's thoughts, was another reference that we chose to offer support for developing the activity (LOUREIRO, 2004). Carvalho (2004) adds the relevance of building the ecological individual, who is oriented to become aware of social and environmental issues while giving a new meaning to their role in Nature along with another individual. The search for new rationalities shaped within an ethical, political, cultural and environmental set for a pedagogical project that only has meaning if thought of as related to the world and in the absence of the dichotomy and hierarchization between such dimensions when building complex views (GUIMARÃES, 2004).

The JBSP and MP were not randomly chosen as starting point for the Expedition. The main motto for raising questions in the field is to build and preserve green areas in a highly industrialized city, such as São Paulo, starting from two scientific institutions. So that the environments be historically treated, in other words, so that we are able to understand that those areas were shaped within a certain period of time and space that were inexorably linked to a net of complex dimensions, the national specificities are taken into account.

The history of science can show us how scientific culture, the communities, personal scientific ethos, schools of thought, social mechanisms for assessing the scientific work, institutions, fomentation policies, education establishments were shaped; as well as the "perverse" effects and other highly important social aspects, since, in addition to allowing us to understand how the Latin American scientific development took place, they shed light on the options in the present (SALDANHA, 2000, p. 14).

According to this view, we highlight the institutional history of the Museu Paulista and JBSP. The creation of Museu Paulista, according to Figueirôa (1997), was directly related to the São Paulo Geographic and Geologic Committee (CGG), which significantly added to the development of natural science in the country and, in particular, in the city of São Paulo, in the late 19th Century. This came combined with the social and political desire to build a monument to the independence of Brazil linked to the feeling of national empowerment that was being built. Herman Von Ihering, zoologist and the museum's first director was one of the characters who stood out in the Expedition for his career as naturalist at the National Museum in Rio de Janeiro,

performance at CGC, personal ambitions toward the museum and responsibility in creating the MP arboretum.

Regarding JBSP, the Expedition place it in the role botanical gardens played in constituting museums of Natural History along with scientific voyages. And when we look at the city of São Paulo, we go back to the creation of the institution pegged to the political needs of the city and country, and to the image of its main creator, Frederico Carlos Hoehne, as well as part of his personal relationship network, which marked his scientific performance within a social circle, presenting his main concepts, trajectory and controversies. The botanical garden is one of the figures that stand out in the fieldwork for directly acting on both institutions and being one of the links throughout the trajectory. Concerning the MP areas, the naturalist worked with the Botanical section between 1923 and 1928. In 1938, the current JBSP is officially open and Hoehne is largely responsible for such creation (ROCHA, 1999). Hoehne's performance as Brazilian naturalist, his work within other scientific scopes, his conservationist ideas, which were in line with social issues from back then, and countless research studies are essential for expanding the connections among science, Nature and environment during the Expedition.

Concepts of Nature, landscape creation and preservation

Historical documents are presented during the Expedition, and they highlight the building process of JBSP, in addition to the concepts of Nature and preservation advocated by Hoehne that were the structure for creating the landscape and scientific practices and concepts. The comparison of text excerpts, images and landscape contemplation over the course of the expedition allows us to understand the initial propositions and changes in spaces occurring between the Old Republic period and the 21st Century.

When it comes to building the JBSP, we notice in the next text the relationship between Hoehne and Fernando Costa, Secretary of Agriculture, Industry and Commerce of the State of São Paulo back then, during Júlio Prestes' office:

> "We invite you to visit our garden and private orchid nursery, …, so that you have an idea of what could be accomplished for the State. Upon contemplating the orchid nursery... Mr. Fernando Costa had the following expression brought to his lips: 'How wonderful, Hoehne! ... If you were able to accomplish this privately, why should you not be able to do so for the State, which has much more resources?' And we replied without delay: 'Yes. The State can and must do so for the sake of educating our people, rising the mindset toward what is peculiar and typical to our country. The State can and must accomplish much more and we are at your disposal to work toward this.'" (HOEHNE, 1947: 115, apud FRANCO and DRUMMOND, 2009).

Texts as the one indicated above are read at strategic stops, such as Alameda Fernando Costa (figure 2), the fieldwork's first dialogue spot. Here, we can recover the remarkable nationalist speech from the 20th Century and the role Nature played back

then. This recovery allows us to understand that the avenue with Brazilian palm trees, Jerivás, was not inserted in the main entrance without purpose, but as a reflection of the 1930s concept, which starred the influence of São Paulo in the national scenario:

"Outdoors, uncovered, we would rather see all the species of palm trees dominating among other types of trees and shrubs; but they are less typical to São Paulo than they are to Hilea. The weather here is excessively cold for such tropic-loving plants. Still, we have and shall have many beautiful representatives of their species in the hope of having the most beautiful real palm tree line in São Paulo." (HOEHNE, 1941, p. 31).

According to Franco and Drummond (2009), Hoehne, as well as other naturalists and intellectuals, was inserted in and connected to a certain political and intellectual context that was marked by the ideas of building a strong State and having a national identity. Thus, emphasizing the native flora was part of that national project and, to this day, these elements, by taking us back to the context of the preceding century, can be noticed within the space. The process of building nationality can go back to the last decades of the 18th Century and to an extensive debate during the 19th Century, when the natural world was approached because of its economic and political importance (PÁDUA, 2002).

For the Brazilian people, among scientists, writers and society in general, science would "give them access to the 'true national essence' and help them overcome the legacy left by the colonial period" (VERGARA, 2004, p. 24). And Nature, the ontological instrument of natural science, was seen as the path leading toward accomplishing that project. The natural dynamics should be understood through science and technological development toward the modernization of the production system and social institutions (PÁDUA, 2002). Since it had already been the product of imagination, fear and admiration on the first Portuguese settlers' part, who arrived to our coastline, Nature, as a result of its magnificence and "lack of order," – or, in other words, that which is to be explored and annihilated – is now understood as an important knowledge-creating resource and, as such, in addition to an esthetic ideal, it also reflects richness for developing a national identity that has yet to be consolidated (RONCAGLIO, 2009).

The value given to the native flora was also related to the concern over protecting Nature, an issue that is often present in Hoehne's speeches, while understanding science as mainly responsible for taking care of the country's natural resources, which essentially reflects one of the topics that were the object of debates back then: the historical heritage (FRANCO; DRUMMOND, 2009). This highlighted the idea that the environment had the potential for adding to what they were looking for back then; in other words, the consolidation of a national identity with the participation of natural science. For Hoehne (1937), teaching botany and building a botanical garden could lead to national development.

The preservation of forests was also associated with the conservation of water resources in the process of urban expansion of São Paulo. According to Hoehne, the Parque Estadual das Fontes do Ipiranga *[Ipiranga Fountain State Park]* was built with the purpose of recovering the vegetation since 1895 when:

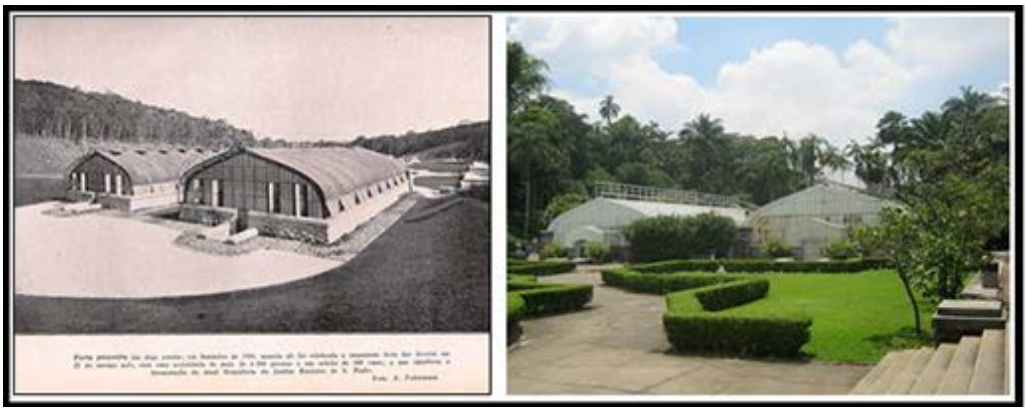
Figure 2: Alameda Fernando Costa. Main entrance to JBSP and first stop of the fieldwork. We observe the Pirarungaua brook, a tributary of the Ipiranga stream. In: Bandeira (2015).

> "The State Water Department started the expropriation of forests, backwoods and small holdings located in the current Água Funda neighborhood with the purpose of preserving the vegetation of the water catchment area supplying the east zone neighborhoods in the city of São Paulo; this area includes the headwaters of the Ipiranga stream and became known as Mata do Governo [Government's Wood], Água Funda Park, Ipiranga or State riverhead, currently known as Parque Estadual das Fontes do Ipiranga." (HOEHNE, 1941, p. 10).

Over the course of the Expedition, we intrinsically analyzed the association between forest and water conservation, by showing the changes in landscape. We noticed the state of recovery of the secondary forest in 1939 and how it has changed until 2011 (Figure 3), thanks to the introduction of trees associated with the natural regeneration. In the images, we notice that the forest canopy, which is located behind the greenhouses, is much taller today and presents a vast diversity of species, palm trees in particular, which were introduced to represent nationality. In this one and other spots of the trajectory, we once again discussed the relationship between man and Nature, which does not always occur exploratorily and bringing about destruction, in the sense of the *modern myth of*

untouched Nature (DIEGUES, 2001), but that can lead to positive interactions that have been developed since the late 19th Century, as a result of conservation concepts.

Figure 3: JBSP greenhouses in 1939 (HOEHNE Et ali, 1941) and in 2011. In: Bandeira (2015)



The concepts about Nature are again discussed about at the MP in the comparisons between the gardens and the arboretum. Many visitors see themselves in a fragment of the Atlantic Forest when they visit the forest with dense vegetation. By comparing the current landscape with that in the images from the text in "The Ypiranga Botanical Garden" (HOEHNE, 1925), we show how the landscape, mostly consisting of a homogeneous environment with very tall trees, was thought out with a scientific and educational purpose to present different Brazilian environments, from "the dry areas of the Brazilian Northeastern region" to the humid lake regions (Figure 4), built amidst tanks connected by pipes, and the "set gives the visitor the impression of actually being in the face of a miniature swamp" (HOEHNE, 1925: 140). The reproduction of environments in the arboretum is associated with the projects of geographic mapping of species, and highlights the research studies conducted at the site, a perception that escapes most visitors.

The reading of the text written by Hoehne (1925), as a document source, reveals the scientific historicity of the site and opens the student's eye to that environment that has once been an important element for the complex science-building process. We took to the fieldwork the controversies of the scientific activity, since the text is the botanist's reply to the article written by Hermann Von Ihering, former director at MP. Hoehne presents arguments aimed at showing to the German scientist "the current state of the Arboretum that he founded and sees it as fully lost to the biological science" (HOEHNE, 1925, p. 124). The botanist's stance seems like a great example for a discussion about building the science branches, which are marked by distinct debates and ideas among the scientific community. By bringing those differences into the discussions about science, we are able to go against a concept of neutrality and objectivity in which we are culturally

Figure 4: Museu Paulista Wood. Above: Lake Region and " Plants that are typical to the dry regions in Brazil" in 1925. In: HOEHNE, 1925: 140; 147. Below: Group of visitors consisting of teachers from São Bernardo do Campo in 2011. Copyrighted photo.

raised (RAMOS; SILVA, 2007), thus building a barrier to approaching the scientific activity in its complexity.

São Paulo and its water resources

In order to foster a more critical view on the sites covered by the Expedition, the historical view makes it possible to develop new ways of understanding environmental education. This strategy allows human relations to be analyzed and integrated into the natural environment. Bittencourt (2003) sees historicity as an indispensable element, since this area of knowledge is able to consider the different relations between humans and environmental exploration, which presents a non-homogeneous history, which, in turn, means that they change regarding space, time and intensity, and it is up to the historical aspects to locate those changes.

This history branch helps us understand with more complexity the nature of today's environmental issues, which "emerge constantly and harrowingly" (MARTINEZ, 2005, p. 28) in a city such as São Paulo. Concerning the Expedition, we reflected on the relationship the city has with its water resources with a critical and historical view. The history process of landscape changing is reflected on the rivers that are invisible to

São Paulo's 21st Century society, exemplified by the Ipiranga stream, and relate to the environmental and social aspect built in the 20th Century.

Environmental issues and the need for the city to rethink its relationship with its water resources, the way we see it, seem to be essential factors for changes to occur, such as that of the Pirarungáua brook, showing that new perceptions emerge when we compare them to the ones we had in the 20th Century. "Today, with the threat of drinking water shortage, we have turned to other meanings of the rivers that were obscured. We have found out that rivers are also part of Nature" (ARRUDA, 2008, p. 11). We are aware that this type of understanding is insignificant, since, still today, the population often demand that their filthy rivers be concealed (SILVA-SÁNCHEZ e JACOBI, 2012).

The urban configuration is marked by the human being and Nature relationship within the spaces built. The changes in landscape that were observed during the expedition present great potential for us to think about the different social interferences with the environment and representations of how we see Nature. The Expedition follows the flow of the Ipiranga stream and one of its tributaries, the Pirarungaua brook, thus allowing questions about environmental consequences that result from different water interventions to emerge. At JBSP's entrance, we problematize the changes the alameda Fernando Costa (Figure 2) has undergone, since it was concrete paved to cover the brook when the garden was first open to the public, thus highlighting the sanitary concepts existing in the early 20th Century. In 2008, the area underwent a revamp that exposed the brook and a process of riparian forest restoration. On the spring track (Figure 1), it is possible to notice the processes associated with the vegetation's function in preserving the soil and regulating the water cycle.

The trajectory travelled by bus from the JBSP to MP follows the rectified flow of the Ipiranga stream, as we see in the satellite image in Figure 1, in an densely populated area with constants floods that are expressed in the use of floodgates by businesses or homes that are close to the riverbank. The observations made about the river and its surroundings allow us to analyze the overall environmental issues at scales that extend from local to regional, covering the Tietê River basin, in a strategy of generalization of the environmental issues. Accordingly, we adopted the urban micro-basins as territory unities for developing the education strategy that can help understand the context singularly and historically (BACCI; PATACA, 2008).

These points for reflection help us understand that the landscape and interferences with São Paulo were not randomly developed, but, rather, they were built under the influence of economic and political views and interests at a certain time and social space. Thus, the Expedition attributes to the Ipiranga stream other meanings with the purpose of understanding the water beyond its physical, chemical and biological aspects, which are solely defined within the scientific content. But it is about understanding it as a powerful component to approach views *within* science, and, therefore, element that is also conceived, handled and used according to the assumptions of social specificities. To that end, the activity relates to scientific, technological and social content in the Brazilian urbanization and industrialization processes (1889-1930). This context is the setting that directly supports the intervention in the water resources in São Paulo, with science

playing an essential role in those changes, since, according to Sevcenko (1998), science, amid its discoveries, gained social grounds at a never-seen-before scale. The discoveries changed how man relates within the most diverse scope, and, because of that change, science was required to intervene more and more directly in daily life issues. Science becomes a global instrument to allow modernity's mottos to be reached and made real. São Paulo was the main stage for this setting. With wealth coming from the coffee bean produced in the Southeast region, the city was able to provide economic and political support for the clear changes the then-called Vila de Piratininga underwent in favor of the urbanization process.

The interventions in São Paulo's water resources give us hints on the process the city was experiencing and the role science played within that context. Once viewed as essential elements for founding the city itself, whose origins are pegged to water resources springing from a hill located between the Anhangabaú and Tamanduateí rivers – which gave it a privileged and strategic topographic location since it was protected from possible hostile attacks and surrounded by the most indispensable natural resource for human life –, the rivers started to be perceived as obstacles to the city's development (SANTOS, 2006).

Two are the essential aspects that we see as being relevant to understand the reasons that drove our rivers to undergo intense reshaping in the 20th Century, to the extent that, today, the city have made them invisible, and where they are perceived, they are found in locations that summarize very well the relationship we have with them, particularly along the marginal highways built along the Tietê and Pinheiros rivers. The desire for modernity and the sanitary mindset in the early 20th Century were well defined by Santos (2006, p. 5):

> "São Paulo was immersed in a context, and it seemed necessary to insert it under the city landmarks, which, in turn should be clean regarding both the need for the sanitary conditions that come with the population densification process and the fact that the elite in power wanted to place it among those that were under the modernizing and civilizing fundaments inherent in the capitalist system, particularly exemplified by Paris and London."

The social desire in São Paulo to fit with the concept of modern city by using foreign examples and elements, as the author points out, is the first fact to be taken into account. The city being treated as an object to be shaped according to the industrial demands to the detriment of social needs is the essential characteristic that symbolizes urban core: ideas imported by the middle class that gained grounds in the city of São Paulo (CUSTÓDIO, 2004). In turn, the growing population in the city created a growing demand for water, which had been made clear since the beginning of the vegetation recovery process for later creating the State Park for water supply. As a result of that, the production and discharge of sewage in rivers – considering that there was no defined destination for that waste – turned sanitation into an issue for the city. In addition to that, several types of diseases were infesting the population and were a concern for the government regarding the workforce, which, in being out of phase, could adversely affect the industrial gear

drive (JORGE, 2012). This situation favors the idea of water resources as being obstacles to the city's progress.

The idea of keeping the city clean, as a matter of healthiness, and following the civilizing and modernizing standards back then is based on sanitation speeches, one of the main lines of scientific thinking that structured the concepts and actions that shaped the city of São Paulo (SANTOS, 2006). We need to make it clear that those concepts, which started with the medical science, support the thinking of urbanists who had the purpose of intervening in spaces that, once reorganized, could be turned into ideal cities. Accordingly, urbanists take ownership of this science's language and make analogies between human body and social body. The treatment given to the city is the same as that given to a living organism, and it is up to the planners to make the diagnosis and act on the city's maladies (COSTA, 2002). According to the author, this type of thinking adds to and justifies the urban projects executed in cities such as Paris, Vienna and Rio de Janeiro. For us, São Paulo must also be included because, since it is already immersed in this context of intense changes, it starts to present certain maladies that hinder its development. Accordingly, just like other cities, this will be diagnosed under sanitary lenses. This is noticeable in the treatment given to the city's water resources.

> "To dominate and tame water resources seems to have been a recurring challenge in São Paulo's urbanization history, closely linked to the scientific concepts in force back then, causing complex effects on occupation and valorization of the urban grounds." (SANTOS, 2006, p. 15).

Custódio (2004) states that, in addition to the legitimate concern over the sanitary issue, to ensure trade flow, a structuring aspect of the industrial capitalist economy, has determined the intervention in water resources, by occupying their floodplains and channeling rivers to provide room for roads, avenues and buildings. These processes show us that "how water resources were seen was gradually changing, and they were given a civilizing character" (SANTOS, 2006, p. 15). Accordingly, it is worth to notice Prestes Maia's Avenue Plans in 1930, which shows how much urbanization used the city's hydrographic characteristics as reference with the water channeling work. This process is called "evil urbanism" (CUSTÓDIO, 2004, p.93) when green areas, floodplains and lack of caution with river spaces are forfeited to favor ideological and economic interests of the middle-class coffee producers and, later, that of the industrial middle class. This choice brought about adverse effects, floods among them, that last to this day.

In the expedition, we problematize São Paulo's urban environment by emphasizing the social and cultural changes brought about by adjustments made to water resources over time. They help us understand how our identity was shaped and discuss it under a critical view at the sites visited, thus allowing this century's social and environmental issues to be debated with increased complexity.

Travels, botanical collections and experiments: the development of scientific practices

During the Expedition, we highlighted the scientific practices and the complexity of their history by delimiting their long-term stay, particularly regarding the botany field. The study of scientific practices is more strongly approached during the visit to the Doutor João Barbosa Rodrigues Botany Museum (Figure 5), located at JBSP, exhibiting objects used in fieldwork and office activities conducted by Hoehne, such as the plant press (Figure 5), work desk, drum for carrying plants during the collection process, plant storing can and magnifying glass for examining samples and photos of the naturalist at work. Many of these objects have already been used in philosophical travels sponsored by the Portuguese Royalty in the late 18th Century, and conditioned the results of collecting, preparing and transporting scientific collections (PATACA, 2011). By reading and interpreting those objects, we were able to understand fieldwork as a scientific practice that is not free of the controversy, techniques and processes that make up science.

This view on scientific practices gets in tune with the proposition of understanding fieldwork as one of the possible spaces for, according to Leite (1995), highlighting the dynamics and the sets of political, economic, social and scientific relations that were put into motion at a given time and space. Just like highlighting the network of knowledge that was being shaped by naturalists engaged in fieldwork by means of correspondences and the references to other naturalists that they contained (PATACA; PINHEIRO, 2005). Accordingly, these practices, when they are linked to several factors, are important elements for developing a new way to look at the history of science and see it "as a specific manifestation of a more general historic phenomenon: that of contextualization of science and the institutional space it occupies in countries located along the coastline of the North Atlantic axis" (LOPES, 1997, p. 16).

The Natural History practices built within this long historical process pervade the constitution of biology as a science in Brazil in the first half of the 20th Century, and the context of creating the Botanical Garden and a series of biology and sanitation institutions, such as the natural history museum and health and agriculture research institutes. As shown by Regina Horta Duarte (2010), the applications of biological knowledge to the health, agriculture and urbanism fields, when scientific activities were juxtaposed with Natural History, made it possible for subjects and art, science and education practices to transit and add the biological sciences to important circles of political power and social and cultural intervention in Brazil. Accordingly, in the first half of the 20th Century, scientists were the protagonists in Nature education, with clear political propositions.

By approaching these historical contexts on site, we were able to show how the objects in the Botanical Museum were created and used, as well as the continuity of certain botanical practices, such as the creation of herbariums, exsiccation, preparation and preservation of seeds, trunks and other plant materials, which were developed in the 17th Century and are still in use today, such as the exsiccated samples displayed at the Botanical Museum (Figure 5).

Figure 5: Left: showcases designed by Frederico Carlos Hoehne for displaying exsiccated samples. Right: Museu Botânico João Barbosa Rodrigues and the plant press. Copyrighted photos, 2011.

New museum concepts and sample collection practices were developed in the 18th Century, many of which are still in use today and helped us understand the botanical practices displayed at the Botanical Museum. Specimens from the three Realms and indigenous artifacts were collected and taken to museums, which started to build a new European imagination realm about "exotic countries." With the science branches, a new meaning was made necessary, and it was marked by the introduction of new thoughts that separated the material plane from the spiritual plane. Nature, previously thought to be a physical and divine phenomenon, started to be understood as a set of phenomena that could be measured, quantified and explored. Thus, the desire to dominate and reshape it according to human needs was intensified and characterized one of the strongest components of modern science. "The new scientific curiosity no longer stays within what is unique and odd, but within what is exemplary" (KURY; CAMENIETZKI, 1997, p. 58). So, according to the authors, the offices are replaced by scientific museums, which no longer have interest in collecting objects such as unicorn horns or mermaid skeletons (now seen as useless and pointless), but in pieces that represent functions or organic structures to build collections that represented the order given to Nature. This led to the proposition of new classification criteria and approach to Natural History.

The collections that underwent a deep restructuring process served as reflection of the new science that was taking hold in Europe: specialized, pragmatic and sponsored by the State. Such movement allowed zoos to get in contact with a wide range of species from different continents for the first time at museums of Natural History, by moving just a few meters, opening drawers and looking at displays. Common aspects of living beings that used to be so distant in time and space started to be shown (LOPES, 1997). Regarding the reasons for these changes we have:

> "... the appreciation of Natural History as utilitarian and morally sound science. The *Muséum* is established as a multiple vocation institution, on the one hand dedicated to the research and teaching of Natural History and related subjects, and, on the other hand, dedicated to educating the ordinary citizen." (KURY; CAMENIETZKI, 1997, p. 64).

The changes in concepts in the face of Nature elements are also present in the role that botanical gardens played throughout history. With the view of a utilitarian Nature, the gardens are first seen as pharmacies for kings and places for experiments to be conducted with plants for the development of agricultural activities, but they also carry an aesthetic meaning. Designed to become private locations at first, they become public visitation spaces and environments to highlight the beauty Nature had to offer, in addition to promoting the acquisition of knowledge and education on the elite's part. In line with the functions that were attributed to museums, both brought "moral benefits from observing Nature, following a line that was often close to the Rousseauian sensitivity or sometimes touching the providentialism of natural Theology." (KURY; CAMENIETZKI, 1997, p. 65).

So that those spaces were seen in a new way, the search for elements in different environments was essential. Although going on a fieldwork to understand Nature is an extremely old practice, it is from that moment on that these activities, in tune with the pragmatism of the scientific knowledge, gain increased systematization in the history of western science (LEITE, 1995). The possibility of discovering new elements that made up the chains of living beings in distant lands was one way to justify scientific trips, according to Kury and Camenietzki (1997). But it is not just that. According to Pataca and Pinheiro (2005), those expeditions motivated both personal interest, such as the desire to consolidate the careers of the naturalists themselves, and that of the State, which funded countless trips, in surveying natural resources, establishing diplomatic relations and developing scientific knowledge. In Europe, those trips predominantly had the colonies as destination.

Planning those expeditions required the creation of a material and theoretical framework, such as scientific instruments and manuals, for classifying and identifying the natural elements. Despite the trip-controlling efforts, the fact is that the fieldwork, unlike highly controlled lab experiments, are limited by space, time and personal factors, referring to the singularities of the people involved, and could change depending on the events that take place in the field. For instance, many of the expected objects could

arrive damaged to the museum, which would prevent them from being studied, stored and added to the collection. When they arrived intact, those products were organized, identified, recorded and studied by naturalists, who, despite being limited to their offices, were essentially linked to such projects. This moment refers to post-fieldwork phase, during which lab data were systematized and even published later:

"The museums equipped with well-prepared colonial collections represented the articulation between the natural, human and territorial world; the fieldwork and the office. They symbolized the appropriation of the natural world, its taming and domination by man before Nature." (PATACA, 2011, p. 131).

The establishment of botanical gardens in the Portuguese colonies is an example that Natural History was also developing in other territories. The gardens start to emerge with the assumption of naturalizing plants coming from Europe, exchanging flora between the colonies and the city, and generate additional funding. Sanjad (2006) explains to us that the garden network was established between 1790 and 1820. The author exposes that this moment is marked by an intense knowledge exchange among territories and is in line with the discussions back then about politics, economy and scientific institutions across the world. The exchange of plant species was intensified between the country's regions and the colonies in Africa and Asia. Projects for establishing Chemistry and Botany courses were resumed with the purpose of deepening the knowledge about the natural resources explored. And one of the valid aspects to be highlighted is that many plant species were even used as bargaining chip for different transactions, which clearly demonstrates the importance of cultivating certain plants and systematizing the knowledge about them

At any rate, botany and natural history practices, developed over a long historical period, involving travels, collection preparation, botanical experiments, creation of museums of natural history and botanical gardens can be visualized in the Expedition along the Ipiranga Stream, and they present the complexity of scientific practices and institutions by engaging a vast network of collaborators. By *doing* science in its historicity, we create new meanings to the artifacts or landscape of the institutions we visited as cultural heritage of the science developed in Brazil.

Final considerations

The exploration of spaces during the expedition represents a summary of how the view on Nature has changed, in line with the search for explanations in the field and the constitution of spaces that consolidated the desire to systematize those new perceptions. Regarding fieldwork, we perceptibly understand the close relationship between fieldwork practices and building the knowledge on Nature. Thus, the Expedition is not only methodologically established as the study of the environment but also historically as one of the strategies for epistemologically understanding the field in shaping natural science.

The articulations built throughout this narrative helped us think about how to establish relations between fieldwork practices based on the history of science in Brazil, and environmental education within a local context. We see the Expedition as an education proposition to demonstrate the importance of looking at the environment under

a historic view, since the concepts of Nature are built based on a given time and space. This establishes in-depth discussions about the causes for our environmental interference, from the techniques of preserving and recovering the vegetation to urban occupation, which was marked by sanitation and hygiene ideals that led to intense soil waterproofing, rectification and coverage of rivers, among other factors.

Thus, we see that going on a fieldwork and paying attention to the invisibility and marginality of the Ipiranga stream, for instance, while pegged to scientific concepts, is one of the possible strategies for understanding the role science plays in social and environmental issues, while showing us that, pegged to other factors, it also plays an important role in human concepts. Furthermore, it greatly adds to a critical environmental education, since the view contemplates several scopes to understand the water issues inside a city that, in its spaces,

> "... can only be noticed by carefully walking through, attentively looking at and interpreting the trace elements, which not always or almost never does the daily pace favor. When properly stitched together, those material marks can retell the "history" of the streams and make it soundly available; in other words, readable and enjoyed in the daily practices that take place within the spaces." (BARTALINI, 2006, p. 90).

The Expedition opens itself to building dialogues among different areas of knowledge, since, from a local context point of view, it makes science concepts clearer by highlighting historical processes of scientific practice development and the meanings of research institutions. Giving visibility to the history of science includes spaces, provides building *within* science and *about* science by highlighting the meaning of objects displayed and technical practices and representations.

The proposition exposes scientific controversies and the recognition of the countless concepts that are enunciated. Science and environment depart from understanding that they are historically built and depend on the social environment in which they are inserted.

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Submitted on: 16/07/2019
Accepted on: 20/11/2019
http://dx.doi.org/10.1590/1809-4422asoc20180154r2vu2020L1AO
2020;23:e01542
Original Article

HISTORY OF SCIENCE AND ENVIRONMENTAL EDUCATION IN THE *EXPEDITION ALONG THE IPIRANGA STREAM*

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HISTORY OF SCIENCE AND ENVIRONMENTAL EDUCATION IN THE EXPEDITION ALONG THE IPIRANGA STREAM

***Abstract*:** In this article we reflect on the development of an educational fieldwork conducted along the Ipiranga River, in which we bring the debates concerning History of Science and Environmental Education closer together, by problematizing the social and environmental issues in the city of São Paulo in a contextualized and critical way. To that end, we established the limits for the hydrographic basin by highlighting the headwaters of the Ipiranga River and the changes it has undergone, as well as the political, sanitary and environmental meanings throughout the 20th Century. We associated the environmental issues with the history of two important institutions located along the river: The Botanical Garden and the Museu Paulista's *[São Paulo Museum]* arboretum. We highlighted the practices, techniques and scientific representations that were developed on the sites, by valuing them as cultural heritage of the Brazilian science.

***Keywords*:** History of Science, Fieldwork, Environmental Education, Botanical Gardens, Frederico Carlos Hoehne

HISTÓRIA DA CIÊNCIA E EDUCAÇÃO AMBIENTAL NA *EXPEDIÇÃO PELO RIACHO DO IPIRANGA*

***Resumo*:** Neste artigo refletimos sobre o desenvolvimento de uma expedição educativa pelo riacho do Ipiranga, na qual aproximamos os debates da história das ciências à Educação Ambiental, problematizando as questões socioambientais da cidade de São Paulo de forma contextualizada e crítica. Para tal, delimitamos a bacia hidrográfica, ressaltando as nascentes e as alterações no riacho do Ipiranga e os significados políticos, científicos, sanitaristas e ambientais ao longo do século XX. Associamos as questões ambientais à história de duas importantes instituições localizadas no riacho: o Jardim Botânico e o bosque do Museu Paulista. Evidenciamos as práticas, técnicas e representações científicas desenvolvidas nos locais, valorizando-as como patrimônios culturais da ciência brasileira.

***Palavras-chave*:** História da Ciência, Trabalho de campo, educação ambiental, jardins botânicos, Frederico Carlos Hoehne

HISTORIA DE LA CIENCIA Y EDUCACIÓN AMBIENTAL EN LA EXPEDICIÓN POR EL ARROYO IPIRANGA

***Resumen*:** En este artículo reflexionamos sobre el desarrollo de un trabajo de campo educativo por el Arroyo do Ipiranga, en la que aproximamos los debates de la historia de las ciencias a la Educación Ambiental, problematizando las cuestiones socioambientales de la ciudad de São Paulo de forma contextualizada y crítica. Delimitamos la cuenca hidrográfica, resaltando las nacientes y las alteraciones en el riacho do Ipiranga y los significados políticos, sanitaristas y ambientales a lo largo del siglo XX. Asociamos las cuestiones ambientales a la historia de dos importantes instituciones ubicadas en el arroyo: el Jardín Botánico y el bosque del Museo Paulista. Evidenciamos las prácticas, técnicas y representaciones científicas desarrolladas en los locales, valorándolas como patrimonios culturales de la ciencia brasileña.

***Palabras clave*:** Historia de la Ciencia, Trabajo de campo, educación ambiental, jardines botánicos, Frederico Carlos Hoehne