http://www.rbhe.sbhe.org.br
p-ISSN: 1519-5902
e-ISSN: 2238-0094
http://dx.doi.org/10.4025/rbhe.v17n2.749

Scientific demonstration classes and the teaching of observation

Katya Zuquim Braghini*

Abstract: The article presents some pedagogical experiences aimed at teaching science, from the use of scientific objects in demonstration classes so as to understand the meaning of 'teaching of observation'. We sought to understand the pedagogical role of demonstration classes which use scientific objects, aimed at promoting a visual education within scientific representations that placed vision, experimentation and demonstration as related actions, i.e. a process of visual education suited to the education of science. For this reason, studies were performed on photographs of scientific demonstration classes of the Centre de Ressources et de Recherche du Musée National de l'Èducation in Rouen, scientific objects of the Archdiocesan Marist College School Museum, and various other documents.

Keywords: observation, teaching of science, educated eye, school material culture.

* Professora e pesquisadora do PEPG em Educação: História, Política, Sociedade (PUC-SP). Doutora e Mestre em Educação pela Pontifícia Universidade Católica de São Paulo (PUC-SP). Pós-doutorada na Universidade Federal de Minas Gerais (UFMG). São Paulo, Brasil. E-mail: katya.braghini@yahoo.com.br

As aulas de demonstração científica e o ensino da observação

Katya Zuquim Braghini

Resumo: Apresentam-se no artigo algumas experiências pedagógicas voltadas ao ensino das ciências, nas quais objetos científicos eram utilizados em aulas de demonstração. O objetivo é compreender o que significa 'ensino da observação', compreender o papel pedagógico das aulas de demonstração com objetos científicos, as quais eram destinadas a promover um olhar educado no interior das representações científicas que colocavam a visão, a experimentação e a demonstração como ações relacionadas, ou seja, como um processo de educação visual adequado ao ensino das ciências. Para tanto, foram estudadas fotografias de aulas de demonstração científica do Centre de Ressources et de Recherche du Musée National de l'Èducation de Rouen, objetos científicos do Museu Escolar do Colégio Marista Arquidiocesano e outros documentos diversos.

Palavras-chave: observação, ensino de ciências, educação visual, cultura material escolar.

Las clases de demostración científica y la enseñanza de la observación

Katya Zuquim Braghini

Resumen: El artículo presenta algunas experiencias pedagógicas dirigidas a la enseñanza de las ciencias, a partir del uso de objetos científicos en las clases de demonstración, de modo a comprender qué significa 'enseñanza de la observación'. Se busca comprender el papel pedagógico de las clases de demonstración con objetos científicos, en la promoción de un mirar educado dentro de las representaciones científicas que colocaban la visión, la experimentación y la demonstración como acciones relacionadas, o sea, un proceso de educación visual adecuado a la enseñanza de las ciencias. Para ello, fueron estudiadas fotografías de clases de demonstración científica del Centre de Ressources et de Recherche du Musée National de l'Èducation de Rouen, objetos científicos del Museo Escolar del Colégio Marista Archidiocesano y otros documentos diversos.

Palabras clave: observación, enseñanza de ciencias, educación visual, cultura material escolar.

Introduction

The study of photographs that illustrate demonstration classes in offices, school museums and science labs in urban schools, whether in Brazil or in European countries, leads to an intriguing question about what is considered the focus of students' look at the turn of the century XIX to XX, when it was a common practice to center the look on experimentation through scientific objects. The pedagogy that stimulated the senses through objects was a reality and the materiality represented in these pictures is a witness to this educational movement considered as modernizing and transnational.

It is clear that the teacher used scientific objects in demonstration classes and that these were understood as an interesting exercise for the teaching of observation. At that moment, it was necessary to form observant subjects who captured better the sense of scientific veridiction, and the objects, of the most varied types, were considered important channels for this purpose to be attained.

Nieto-Galan (2011) states that the forms of communication of science were varied and that this resulted in the configuration of different spaces of scientific practice and also in the creation of what the author calls 'publics of the sciences'. Between the XVI and XIX centuries, among the actions that stand out most as an element of diffusion of the sciences, are the classes of demonstration of experiments, which, in most cases, were developed through scientific objects in theaters, Aristocratic salons, museums, schools, etc. The 'show' demonstration combined entertainment with instruction for a diverse audience (Nieto-Galan, 2011).

Lehman and Bensaude-Vincent (2007) tell that the public performances of Chemistry in France caused an 'exciting sensory experience' because the aim was to be seen, heard, smelled. However, the authors caution that such presentations were instructive and attractive, but were not exclusively about entertainment. Although such a practice was a hobby of many amateurs, it also had a character both serious and ambitious.

The idea of an education that instigated the action and behavior of the observer was not exclusive to scientific ideals; it was also reflected in technological, artistic and philosophical discourses. It is said that the practice of scientific observation is a product and constituent of what is understood by modernity and can be understood not only by the emergence of a type of observer, but also by objects and signals whose effects coincide with the visuality itself (Crary, 1992). The observer must be understood as a historical product of certain practices that take place in places and institutions, whose particular techniques and procedures result in subjectivation processes and, in this case, concern the understanding that the observer is someone who conforms his/her actions, his way of looking, by means of rules and codes presented in science classes.

In the case of science teaching, there was an enthusiasm for observation because it was presented as a powerful form of persuasion, refining one's own senses, a calibrator of judgments. The association between observation and experience was direct. However, the union of these two actions also has a history: they came to be associated, in the scientific process, only in the passage from the XVIII century to the XIX century (Daston & Lunbeck, 2011).

Therefore, understanding what was meant by 'observation' in science classes leads to the discovery of rules, codes, and practices that have created a system of conventions and limitations about what should be seen and learned in class. In this system, the forms of behavior considered appropriate to observation in a teaching process that depended on the direct visualization of things were established so that knowledge could be obtained. Such an aspiration was dependent on the objects put into action, since from the relationship between observation and experience emerged the postulate of what was to be observed and how it would be observed.

The emergence of new epistemic codes in Science, which had objectivity as a dependent of work objects, introduced a new dynamic actuation of the body for scientific studies, taking into account the use of instruments and methods of work that comprised the repertoire of a "[…] mechanical observation […]", seeking a "[…] trained judgment" (Daston & Lunbeck, 2010, p. 18-19). It can be said that in an education that aims at a trained judgment, observation is understood as an action that enhances the senses, which prepares in the student the basis on which human knowledge is constructed, that is, the capacity to perceive, analyze, abstract, compare, generalize, synthesize (Valdemarin, 2004).

The scientific objects (precision instruments, machines, models, diverse apparatus) are the historical materiality capable of evidencing different traditions in the teaching of Sciences, either to evidence a 'canon' or to institute new pedagogical practices, as already discussed by researchers like Herring (2011) and Kremer (2011). This discussion opens the possibility of thinking about the role of scientific objects used in demonstrations that were established as school practice in science teaching and, more specifically, of understanding what it meant, starting from things, to teach a fundamental action for the own understanding of what Science was: the act of observing.

In this text, we discuss some pedagogical practices organized with a group of didactic objects that became part of the schooling universe in its search for empirical knowledge and the production of the sensorial stimuli that are part of the operation of science teaching. The classroom space represents a curriculum, often hidden, in which the dialectics between teaching, with its protocols and knowledge tacitly assumed as legitimate, and learning, with its judgment, that, being critical or not, establishes conformations and changes in the presentation and dissemination of this knowledge

If it was necessary to observe something, what was to be observed and how? How did scientific materials serve the formation of the observer subject? What did 'observing' mean in science classes?

The 'ways of seeing' in history depend on the study of social relations and the regimes of sensitivity that constitute the patterns of imagery, the formats given to images in time. Demonstration classes direct the students' look to this dynamic representation that is experimentation, fixing images about Science; they are symbolic constructions arising from the relationship between who looks and what is looked at. Transformations in the visual representations are the result of an ample organization of the knowledge and the action of power, which modify the visual capacities of the subjects. Such changes can be analyzed in the history or in the interior of different cultures, which implies taking into account the diverse possibilities of creating scopic regimes or thinking that discourses and practices make up the different forms of visual experience in historically specific circumstances. Vision is a historical construction that depends on the understanding of social practices that take place in particular institutions, in the case, at school and in demonstration classes, triggering different modes of subjectivation and new methods of administration of the look.

From the methodological perspective, the text focuses on the study of objects, teaching prescriptions and textbook content. Also were analyzed photos that show the use of such devices in demonstrations in the classroom. The purpose of this article is to interrelate this documentation.

The term ‘scientific object’ is used as a collective name to designate models, machines and apparatuses considered central elements of what should be observed, in view of the privileged focus of their functions by the hand of teachers. Pestre (1996) states that the object’s status depends on the context in which it is put into operation. Brenni (2011, 281) also refers to various categorizations of scientific instruments, depending on the context. According to the author, teaching instruments, in the didactic case, are used “[…] merely for illustration and for the reliable presentation of the facts in a clear and convincing manner”.

Scientific objects oscillate between being the portion of materials produced especially for school didactic purposes and another of which, adapted by the school, are designated as “[…] school material culture” (Souza, 2007, p. 177). Teaching objects or objects for education in the Natural Sciences are the terms proposed by Meloni (2014), which states that not all artifacts found in scholarly scientific patrimony are scientific instruments of precision, but materials of daily use that were adapted to the class, such as coffee filters, spoons, glasses etc.

The material culture is understood in the text as a dimension of knowledge with its own code, which means the possibility of registering indicia significations taken from the material, according to its own nature, because although they are associated with the verbal codes, they are not totally imprisoned to them. We opt for the study of material culture in its interaction with concrete aspects of human life and we think the meaning of the experiences through the manipulation of the objects presented throughout the study. The objects analyzed in the article, mentioned in textbooks and presented in photos, appear in the collection of the School Museum of the Marist Archdiocesan College of São Paulo and were manipulated to collect data and information pertinent to the theme. They are: the Wimshurst Machine, the Gravesande Ring and the Ruhmkorff Coil.

Objects presented in the photographs were put into action, under the judgment that, when the person triggers them, also thinks, withdraws data of their operation, draws hypotheses about their uses, etc. In other words, it is understood that “[…] materiality is an essential protagonist of motor conductions as a matrix of subjectivation” (Warnier, 1999, p. 14). Therefore, some of these objects were manipulated as requested in the exercises of the books, so that, through the simulation, more information could be sought for the research, as aspects of the operation and procedures of use.

In the case of the study of the photos presented in this text, we opted to perceive, in the field of visuality, the recurring elements that were presented as focus of attention and celebration. Materiality is also understood in its spatial position, in the ways in which it has been arranged in school spaces, taking into account both the arrangements dictated by legislation and the mediations established with it by teachers and students. In this case, the study of images was based on the withdrawal of information about "[…] models and modalities of the 'look'" (Meneses, 2003, p. 31, author's emphasis), which means understanding the roles of the observer and what, during such practice, is registered as central in the focus of the images.

We searched 42 photos of science offices, classrooms, auditoriums, laboratories and amphitheaters of several French schools. However, in the article, only three of them are analyzed[1]. It was also analyzed a photo of the Laboratory of Chemistry of the Archdiocesan College. Classrooms may or may not have the auditorium configuration, but were chosen actions that favored the demonstration in classroom. The textbooks covered are available at the Library of Didactic Book of the Faculty of Education at the University of São Paulo (LIVRES - FE-USP). The Journal of Education of the State of São Paulo is part of the Archive of the State of São Paulo (APESP).

The scientific apparatus in demonstration rooms: what does it mean to observe?

Fernand Buisson, in the *Dictionary of pedagogy*, in the entry 'Education of the senses', affirmed that the Natural Sciences and their tools were knowledge of fundamental importance. The Natural Sciences were described as "[…] the most important of all arts [...]" for the "[…]

---

1 The French photos refer to the period between 1890 and 1957 and represent facts that occurred in normal schools, lyceums of boys and girls, gymnasiums, boarding schools. These photos have been classified according to the indication presented in the photo or separated according to the indication given by the archive. It was found that science offices were usually the environments where materials were stored in lockers, these also called school museums. There were offices that were rooms attached to the classroom or labs; others had rooms set up for study in the office. The photos were searched at the Centre National de Reserche Pedagogique do Muséé Nationale de L'Educación in the city of Rouen.

use of our eyes to teach" (Buisson, 1887). The relationship between observation, objects and eyes was demarcated as a fundamental necessity.

In the entry 'Observation', the French reformer stated that the scientific method was his great teacher. According to his thinking, having a good observation meant clearing the senses first. Then the observer had to get rid of prejudice and early explanations, because the action performed thoughtlessly was connected to the common sense and thus subjected to errors. The best learning would be the accuracy of results, through the use of methods that would determine more accurate human actions. The observer subject, in addition to being insightful, should be patient, attentive, suspicious (Buisson, 1887).

Rui Barbosa, in his translation to Calkins of *Primary object lessons* (1950), pointed out the didactic character of the operation of the senses – instructed by things and not about things - and demonstrated how the class work was operationalized. The habits of observation served as a means for stimulating the sensations that precede perception and attention; created readiness for classification; training for discrimination of other properties; expanded the capacity for description (Barbosa, 1950).

In the didactic book *First notions on science*, it is recorded that the method of 'observation' and 'experience', by which 'great results in science' were obtained, was exact in nature and accurate. Scientific observation was concerned with rigor and precision, in order to seek 'more accurately' the results of research in general rules or laws of nature (Huxley, 1917). This author shows that what we grasp through the senses is called 'thing' or 'object' and that the information captured by this action is called 'sensation'. According to the content of the book, one must be attentive to the understanding of the 'cause of things', for this reason the attentive observation of the "[…] chain of causes and effects" (Huxley, 1917, p. 6) is encouraged.

Throughout the XIX century, technologies geared to the production of science have gained the status of great presenters of new worlds and have come to have a special meaning for the said science classes. They were guiders of meanings, revealing meanings of Nature in its operation and under different scales. They were not secondary elements in the construction of hypotheses and analytical categories, since many of them would not have been postulated without the invention or the operation of these objects. That is, scientific objects associated with institutional and discursive conditions, which, at the time, promulgated what would be 'scientific knowledge', were established as important material and defined the idea of an observer subject.

However, this was not always the case: previously, in the XVIII century, in the search for scientific fact, presented in the form of natural laws, such devices were seen as links between knowledge dependent on the weakness of the senses and knowledge governed by the knowledge of method. An important part of the scientific revolution was the creation of an experimental method and the production of conventions on the proper use of the instruments (Van Helden & Hankins, 1994).

In school application, they can be presented in a simplified or reduced scale, either for familiarization and training purposes or as a means of historical apology for a scientific event (Heering, 2011). The school replications of the experiments of composition and decomposition of water made by Lavoisier through instrumentation are examples of pedagogical practices whose didactic version, besides presenting the phenomenon, wanted to demarcate the scientific event. Some objects were named as scientific toys (Brenni, 1997), used in demonstration classes to entertain, attract attention, and present scientific phenomena in a playful way.

Microscopes were exalted as great learning tools, and didactic books constantly instructed on how they functioned. They were noted for presenting a world "[…] made up of very small parts called cells that we can only see and distinguish with the aid of a microscope" (Potsch, 1923, p. 13). More than that, there was an obsession with naming the discovered microscopic universe. It was important to know the functions of each of the parts observed.

Microscopic images of worlds have become a form of immediate visual knowledge in teaching *tableaux*, known in Brazil as parietal pictures. Such pictures were part of a long tradition of teaching and were part of the school's visual didactic material. Among the topics related to the sciences, its images allowed to see internal and external parts of plants and animals, to distinguish the organs, with their respective names, and to know the classifications that Botany and Zoology had built on Nature.

In didactic books, microscopic parts of animal and plant tissues were presented as images, either for viewing or presenting their names [2]. For

2 About the presentation of microscopes: *Noções de sciencías physicas e naturaes…*, 1927 and *Elements of natural history...* (1917). On the microscopic visuality:

example, cross-sectional observation of a germinated grain of wheat: a) tegument, b) albumen, c) embryo, d) lumula and covered radicles (Hooker, 1894). Even the operation of the microscope itself is presented, and its constituent parts are distinguished. As shown in the book *Notions of physical and natural sciences*, the microscope is thus composed: O = ocular, o = objective, a) object door, L = lens for sunlight entering on the object, M = mirror for the same purpose, OABo = instrument tube or cannon (*Noções de sciencías physicas e naturaes…*, 1927, p.209).

In the case of Zoology, sub-item of the discipline of Natural History, taxidermied animals had the appearance of life; the respective natural environments were staged, creating an atmosphere of exoticism and familiarity, depending on the habitat of the species. Madi Filho (2013) presented the 'biography' of the uses of taxidermied animals in school activities carried out during the preeminence of the intuitive method, showing that the most important element of these classes was the visual presentation of the stuffed animals to the students.

Thus, the animals were observed in their respective morphologies. The teacher would describe the animal and then educate the student's look at the morphological characteristics, that is, what was significant in the specimen and which differentiated or resembled animals. For example, based on the paw connected by interdigital membranes, a seagull would be classified among the web-footed birds. Once this more general work was done, one could follow a more specific classification and, by the characteristic of the long and sharp wings of the seagull, this one could be assigned to the suborder of longipennes. Observing, in the case of Zoology, meant comparing and classifying animals, differentiating them or grouping them based on details of their external anatomical characteristics, paying attention to their morphology (Madi Filho, 2013).

In XVIII century scientific offices, devices were designed especially for the demonstration of a physical effect or law, in which case they would be didactic adaptations rather than research tools. They emphasized a theory, presented themselves as audience entertainment, and had the power to disseminate scientific knowledge to a broad audience.

Nieto-Galan (2011) explains that in the XVIII century, demonstrations to present electricity caused 'almost irrational' feelings in the audience. According to the author, natural philosophers were

---

Broglie (2010, 2012).

sometimes perceived as magicians and as part of a business. They were presented in popular theaters and galleries of practical science, with their magic lanterns, optical illusions, dioramas and panoramas (Nieto-Galan, 2011).

An explanation for the transfer from the demonstration practice to the school environment would be the fashion of Physics offices that emerged in the late XVIII century in France (Hulin, 2007). According to the author, Sigaud de la Fond, known in France for creating the first offices of Physics at the Collège Louis-le-Grand, even taught private lessons for the preparation of devices and experiments. Physics demonstrators rushed into colleges to sell instruments. In 1802, Antoine-François de Fourcroy, French politician, chemist and reformer of higher and secondary education, reported that "[…] instead of the course of Physics or Natural History […]", demonstrators showed electrical or magnetic phenomena, experiments on vacuum and magnification of objects in the microscope (Hulin, 2007, p. 64)[3].

The idea of presenting the experiment in an expository way has another historical explanation: the audiences were considered as distributors of information and, at the same time, fixed to the idea that they received knowledge from the professorship (Lehman & Bensaude-Vincent, 2007).

Scientific objects were acquired or relocated according to the convenience and curricular regulations of the disciplines. The principle was to place them in the focus of the students, emphasizing what each

[3] This last reference indicates a disagreement as to the form of teaching, that is, it indicates that a 'true' teaching of Physics would not be immediately related to the visual presentation of the experiments. In the State of São Paulo, there were those who considered teaching through devices with reservations. First, much credit was given to them; then it was stated that only its presence would not guarantee learning. According to João Bellegarde, in the Revista de Ensino, the excess of machines and apparatus was compared to the growth of a weed in the 'fecund tree of public instruction' because the principles of Pedagogy were lost upon the functioning of machines, treated with irony, 'That everything is taught and everyone learns!'. He predicted, ironically, that in a short time the teacher would be dismissed, because the teacher was the machine. Thus, he criticized Cesário Mota's São Paulo policy: "This didactic monomania has only served to compromise and distract the attention that should be surrounded by the real teaching books worthy, for the benefit of those who learn, of studious youth" (Bellegarde, 1902, p. 84).

discipline understood as observation (Bocchi, 2013). It was the art of arranging objects so that they could be visualized in specially built spaces, such as science offices, school museums and laboratories.

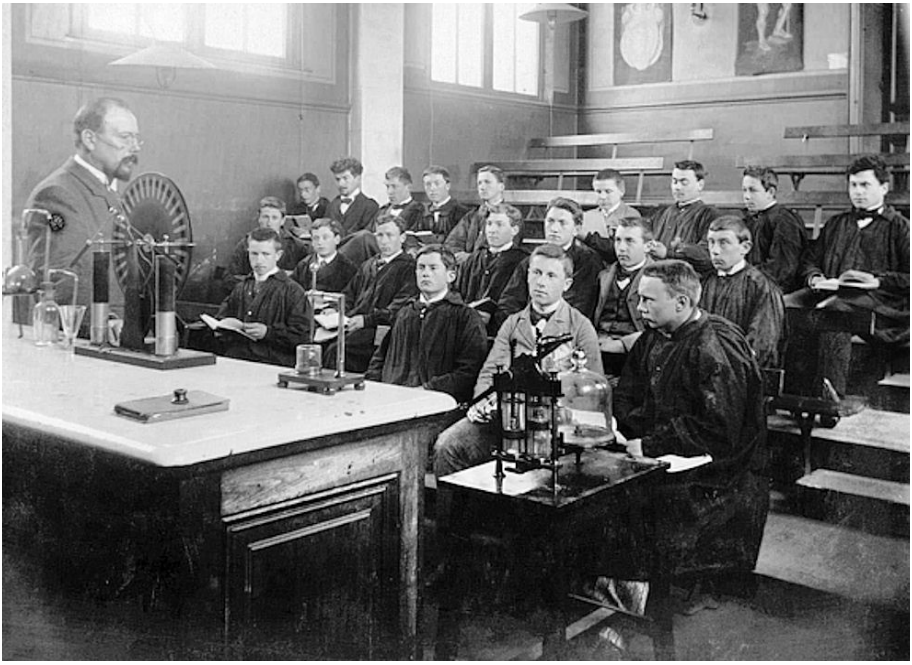
This study analyzes four photos and an illustration. The photos below (Photos 1, 2, 3) are three records of French demonstration classes. Following is an illustration of how the electric charge was transferred to a Leyden bottle. Finally, Photo 5 shows a class held in the chemistry laboratory of the Marist Archdiocesan College of São Paulo.

From a visual perspective, the three French records show similar situations in close contexts; the photo of the Brazilian case demonstrates a laboratory of the early 1940s. In different schools, in different spaces, inside auditoriums, a laboratory of Chemistry and a class, we see that the focus of the student focuses on the presentation of the teacher and scientific objects. Benches with varying scientific objects are the central part of the actions. Students are placed in the audience, rather than those who should pay attention to the material exhibitor.

In the case of the French examples, we see the use of scientific apparatuses aimed at teacher training in normal schools, for the training of girls in the Lyceum and for the teaching of young men in the upper primary course between 1900 and 1905. In the presentations, we perceive the use of electrostatic instruments, such as the aforementioned Wimshurst Machine (figure 1) and Ruhmkorff Coil (figure 3), but also activities with pneumatic pumps (figure 1, 2, 3).

No caso dos exemplos franceses, vemos o uso de aparelhos científicos voltados para a formação de professores em escolas normais, para a formação de moças no Liceu e para o ensino de moços no curso primário superior entre 1900 e 1905. Nas apresentações, percebemos o uso de instrumentos do gênero elestrostático, como a já citada Máquina de Wimshurst (figura 1) e a Bobina de Ruhmkorff (figura 3), mas também atividades com bombas pneumáticas (figura 1, 2, 3).

Photo 1: Class with emphasis on the use of the Wimshurst Machine at the École Normale d'Evreux (circa 1900).



Source: *Leçon de physique...* (1900).

In photo 1, we see that the teacher is beside the experiment table. Most students, seated, observe the main action of the Wimshurst Machine. Some students seem to take note of something, others holding books seem to follow the possible lesson. The teacher stands in supervision. Under the table there are other objects, and the highlight is the two-cylinder Geryk Pneumatic Pump. The edification of the inclined audience further emphasizes the centrality of the teacher and his experiments.

The Wimshurst machine, electrostatic, could be sold in various sizes. If it was not handled correctly, it would produce strong discharges. The use of space, the position of the subjects in front of the instrument and the fact that it is not of simple management highlight the role of the teacher in the action of the lesson.

The pneumatic pump is also a machine, that is, it is a set of items used in association to produce and transform energy, imparting movement to the cylindrical axes. Other accessories can be attached to the pump to create a vacuum in cylinders, spheres, etc.

Both are powered by the direct handling of cranks and have different stages of conduction of the handling, which are the presentation of the class itself, being, therefore, machines for operational study.

To explain the elastic nature of gases, for example, J. Lamglebert's book of Physics says:

> This gas expansion is experimentally demonstrated by placing a bladder containing a small amount of air on the container of a pneumatic machine. As the vacuum in the vessel is established, that is, the pressure decreases, the bladder swells more and more, expanded by the expansive force of the air it contains, no longer balanced by the outside air (Lamglebert, 1904, p. 4).

The idea was to explain that there is elasticity in gas, but for this activity to be carried out, it was necessary to be aware of the operation of the vacuum pump, to connect the pump hoses to the glass container with the dome from which the air is taken, seal the dome, turn on the pump or sometimes manually remove the air by means of cranks, etc.

At the Archdiocesan School Museum, through direct contact with a vacuum pump, it was found that this served as a module for the coupling of several species of domes, since it was a 'multipurpose' device whose purpose was to demonstrate the various properties of the air for the course of Pneumatics. In this way, it was possible to experience the absence of sound in the vacuum, to prove the existence of oxygen, etc. The technical knowledge could be acquired by following what was written in the didactic book, but with the present machine, there was a direct, manual handling that could seal the success or failure of a lesson, depending on the teacher's experience and management[4].

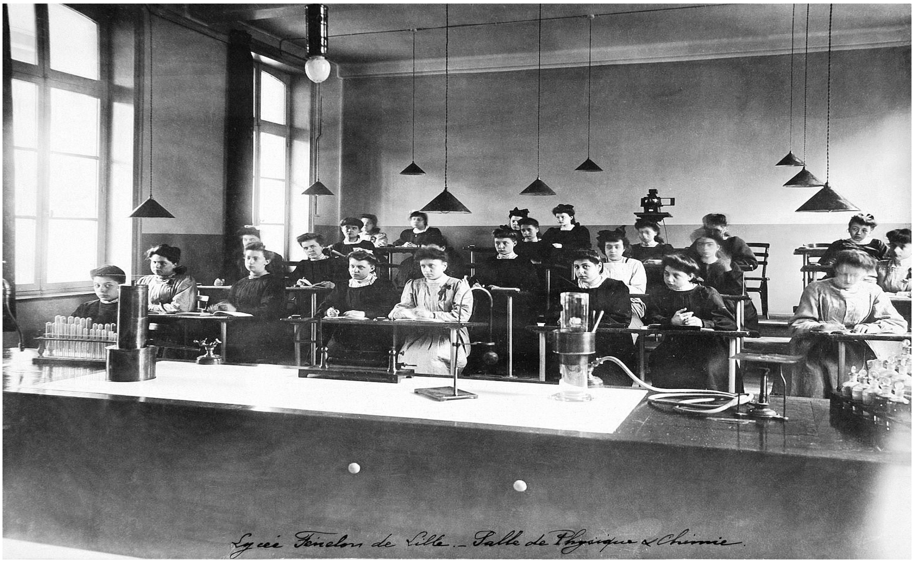
---

4 Several models of air pumps have been improved throughout the XX century. Toricelli's barometer is pointed as the first instrument for the measurement of atmospheric pressure and for proving the existence of the vacuum (1644). In turn, at the Crystal Palace Universal Exhibition in London (1851), there were 12 exhibitors of air pumps. Therefore, there is not only one model of air pumps but a series of them, with different modes of operation and with evolutionary markings that demonstrate, at the same time, the different ways of doing, which were also presented as commercial advantages (Turner, 1983).

In the Lyceum class (photo 2), most young normalists seem to pay attention to something that is not visible in the picture framing. We see that, at the center, is the demonstration bench with several scientific objects. Once again, the room, in an auditorium format and gives the impression that the focus is concentrated on these materials. The demonstration table displays scattered materials and accessories, because in order for them to work, they need other devices. It does not exactly appear the focus on a specific experiment, but rather the targeting of the display axis to the devices used in the demonstration.

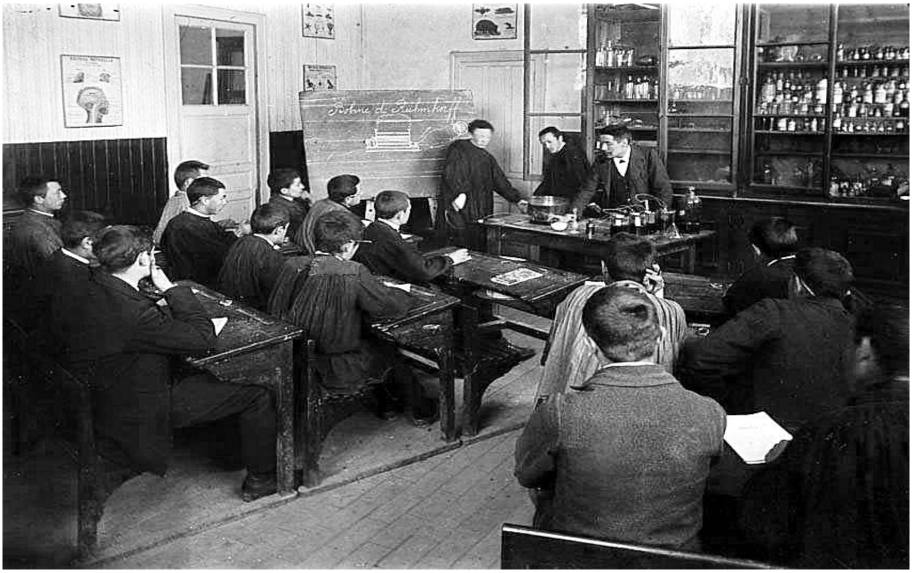
At the center of the table, there is a 'Gravesande Ring', usually used in the course of Calorimetry to prove the dilation of metal with the application of heat. Its operation consists essentially of showing the public that the metal ball held by a chain passes, vertically, by a ring while it is cold. However, as it is expanded by fire-induced heat, it is no longer possible to pass it through the same orifice (Ganot, 1884).

Photo 2: Physics and Chemistry Hall of the Lycée Fénelon de Lille (circa 1905).



Source: *Lycee Fenelon de...* (1905).

Photo 3: Physics Lesson with Ruhmkorff Coil at La Ferté-Macé Primary School – 1900.



Source: *Ecole primaire superieure...* (1900).

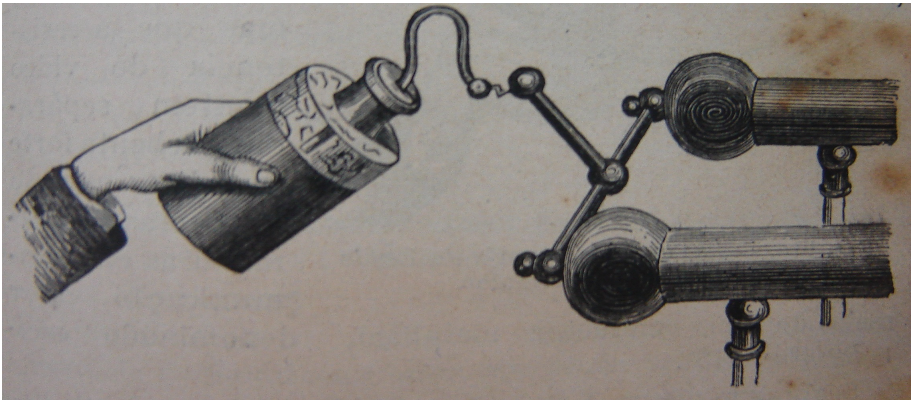
Objects related to electricity are present in large numbers in scientific collections, whether they are scholarly or not. At times, it was possible to invite spectators to participate in experiments so that hair would shiver and hands attract small pieces of paper as a result of electrification (Castel, Mocholi & Sánchez, 2003).[5]

Photo 3 shows a male classroom, with students turning their backs to the photographer, evidencing the direction of focus for the demonstration by the teacher at his desk. The teacher seems assisted by two students. On the board is written ‘Ruhmkorff Coil’. This coil has the function of showing that “[…] electromagnetic induction transforms low-voltage electric currents, such as batteries, into very high voltage currents” (Thesaurus, 2016).

[5] These experiments occurred for a long time in Physics classes and, according to the authors, were the stimulus for A. Ganot for the publication of his book *Cours de Physique* (1875), “[…] purely experimental and without mathematical calculations” (Castel et al., 2003, p. 342)

It can be seen from the objects placed on the table and presented by the teacher that this is an Electrostatic class because, to the extreme right of the teacher, there is a Volta condenser and, just beyond, the Leyden bottles, which serve to store charges and cause electric currents. The book *First notions of physical and natural sciences* (1923) shows the way this charge storage maneuver was made (photo 4).

Photo 4: How to charge a Leyden bottle – 1923.



Source: *Noções de sciencias physicas e naturaes* (1927, p. 265).

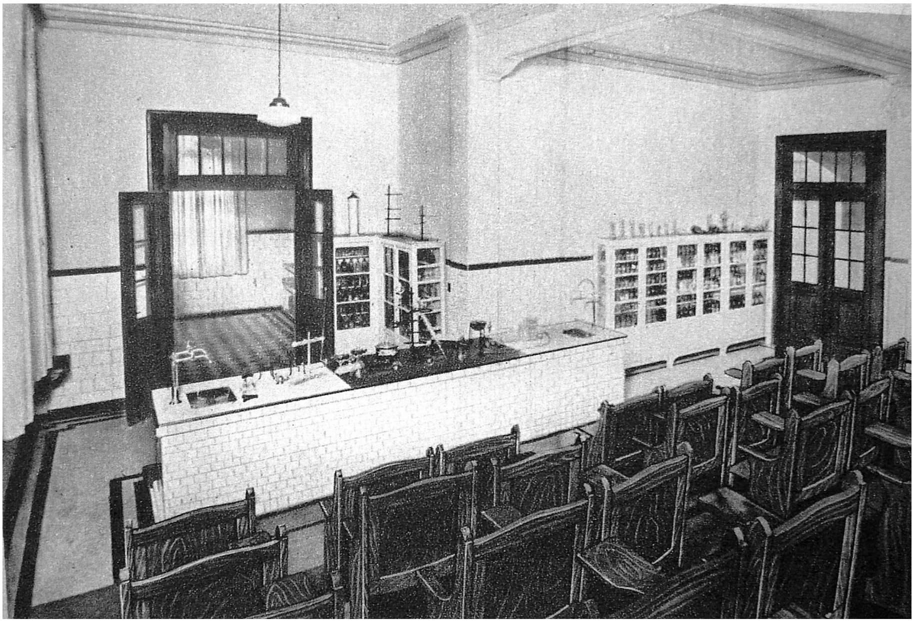
The metal communication rod of the condenser is brought into contact with an electric power source from the electrostatic machine and accumulates an electric charge. If the operator touches the rod, gets a shock. The condenser has a glass bell, in which, sometimes, chopped, metallized sheets are introduced, which appear to float when there is distribution of electric charges inside the machine. Therefore, the set with coil, bottles and condenser formed a complete apparatus of demonstration of the electricity.

According to the content of the didactic book of Miguel Milano (1922), it was important the presentation of the physical phenomena by means of machines and apparatuses. The electric force could be known through the presentation of 'inductive and induced currents' and the best way to present them would be by means of coils. According to the author, Ruhmkorff Coil is the most important 'induction machine' of currents (Milano, 1922). The knowledge of the issue is concentrated in the functioning and identification of devices, as well as in the observation of the phenomena that can be demonstrated through them (Milano, 1922).

Therefore, in this case, with observation it was understood the presentation of the friction to generate electricity, passing through conducting bodies, the electrical capacity of conductors, the effects produced by the electric discharges, the electric dynamics, the electric induction, etc. For electrical demonstrations, there were all types of machines and possible appliances: electric machines, Leyden bottles, batteries, electroscopes, lightning rods, compasses, Volta's battery, etc. (Lamglebert, 1904).

In didactic books, electricity, to mention another example, was understood as a 'thing'. The idea was to present everything that was connected or related to the series of phenomena that it produced, without it being known, for sure, of what it was. The interest of the studies focused on "[…] attractions, limb shocks, chemical combinations, light effects, heat effects" (Huxley, 1917, p 171).

Photo 5: Laboratory of Chemistry.
Marist Archdiocesan College of São Paulo – 1935.



Source: Memorial do Colégio Marista Arquidiocesano de São Paulo (1935).

In the case of the Laboratory of Chemistry of the Archdiocesan College of São Paulo, Bocchi (2013) realized that, in 1935, the construction of the new laboratory in the auditorium arrangement was preferred (photo 4). According to the report of the federal inspector, the space was thought based on the regulations issued by the Ministry of Education and Health, so that the student could "[…] study practically and to the maximum benefit Chemistry" (Memorial, 1935). For the benefit of chemistry, it was understood the act of centralizing the experiment, demonstrating that the practice of visualizing instruments and exercises done in the manner of a conference was not easily abandoned.

The program content presented in the didactic book *Elementary lessons of physics* demonstrated that the teaching of the discipline of Physics-Chemistry was directed to the knowledge of the phenomena of nature, but also to the knowledge of the scientific instruments, seen as teaching contents[6]. Scientific objects in school laboratories were not understood only as didactic resources for the activities;[7] themselves, their respective functions and constituent parts, were described as part of a program of studies. Among the instruments or objects of study mentioned in the book were: lever, scale, areometers, hygrometers, pneumatic machine, pumps, thermometers, electrophores, electroscopes, magnets, mirrors, lenses.

Brenni (2011) is categorical in stating that some machines were hardly used, since the number of hours devoted to the course was limited considering the time spent by complicated demonstrations. The appliances

---

6 Considering the teaching programs of Colégio D. Pedro II, referential college of the Brazilian secondary education, the discipline of Physics-Chemistry was jointly taught from 1850, according to the Examination Program of the institution. Then, in 1856, the disciplines were dismembered: Physics for the 2nd grade, Chemistry for the 3rd grade. In 1858, still separated, they became, respectively, contents of the 5th and 6th grades. They were again unified in 1862, with the name 'Notions of Physics and Chemistry'. Soon after the proclamation of the Republic, the Teaching Program of the National Gymnasium organized by the Reform of 08/11/1892 and provided for in the Regulation of November 22, 1890, article 6, continued presenting the discipline in a unified form. However, different activities were presented in laboratories, remaining until 1915. Only in the teaching program of 1926, there is a clear separation between the two disciplines, taught in the 4th and 5th grades (Vechia & Lorenz, 1998).

7 According to the program of studies of Collegio de Pedro II, authored by professor Saturnino Soares de Meirelles (1828-1909).

were not easy to operate and not all teachers had the help of skilled trainers, which made it difficult to use

Nevertheless, correctly or not, direct observation of the same objects presented in the photos and found at the Archdiocesan College shows the opposite. In the case of the Deleuil's Air Pump, acquired before 1906, there are wear marks at support points which are more evident than elsewhere in the machine - at sites of engagement and disengagement of parts, markings on glass. Such marks indicate the handling of objects and are a kind of cartography of action: they point to the manual movements necessary both for the understanding of the machine and for the possibilities of practices with the object. The devices call hands to action and, when observing them, seek the points of support that are already marked. The layers of use are perceptible, as sediments inscribed on the object over time, telling the usage history.

Final Considerations

Thinking about observation techniques related to demonstration classes means thinking about cultural processes - habits, visual customs, concentration on the focus of the class. In this way, one can understand that visual aspects and relationships between people and objects, as a source of cultural transmission, present the visual process of identification and understanding of the world by the training of the observing vision.

The didactic strategy of scientific demonstration had as fundamental interest to show the audience the observable actions that, directly or indirectly, were constituted to prove, mainly, the plausivity (and, sometimes, the falsity) of the presented hypotheses for the phenomena. The scientific demonstrations presented in the didactic books as replications considered the repetition of the experiments as the pedagogical foundation for the study of a scientific theory. Moreover, through replication, the educator always had a new opportunity for intervention to guide the student's look to what should be the focus of observation.

The demonstration, as a pedagogical activity, at the same time as it had a scientific character, appeared as an activity to call attention, although it was not problematic. The object was presented by sequences of procedures previously stipulated by the experimenter. Therefore, an action that did not necessarily stimulate the scientific problematization was divulged, since, in the act of the demonstration, the question was already posed and the explanation, evidenced. The significant mode of observation was standardized.

According to the analysis of didactic books, from iconography produced to sales catalogs, the test of classroom observers would go through the following ritual: the demonstration of the device, the machine or the instruments. Such demonstrations had the interest to make the audience appreciate not only the scientific phenomenon to be investigated, but the play itself. The construct of the machine was at stake, as well as its functioning, the integration of its parts. The play domesticated the eye and, in addition to individualized knowledge, it was sought a standardization of group observation, since the presentations were made to confer knowledge to audiences.

The scientific apparatus was a mediator of experimental knowledge and had an important pedagogical role in the process of scientific education, since it illustrated, made visible and sometimes palpable to a non-scientific audience a phenomenon of nature presented in the form of 'fact'. It is interesting to examine the requirement of accurate observation by prescribing, for and in teaching, practices, procedures, gestures, habits, skills, body disciplines and also the materialities of the instruments and objects that constituted the collection of school materials used for teaching a 'well done' observation. The proposals of pedagogical practices shaped the subjects according to what was understood as spirit and scientific attitudes.

The audience followed the acts of the teachers, taking into account the operation of the instrument or the model, seeking to understand the phenomena, the scientific facts and the theories that were mobilized by them and the respective functions of each of the apparatuses. The procedure was presented as an incorporation of knowledge, a dynamics internalized by the body during the action that the teachers exerted on the object. This knowledge was performed by the perception of the points of contact between the teacher and the device in the form of a motor memorization.

By means of planned classes with these apparatuses, it was sought to stimulate an accurate perception, the selection of what was worth to be seen and registered, separated from what was merely supplementary. The look separated what was necessary from the images, since it would be taken to a motor synthesis that did not allow much trouble for the class to succeed. The search for veridiction institutes vision as the fastest way to acquire knowledge. The 'observation' of the students would be the association of vision and hearing in the search for understanding the points of the class and the different demonstrable stages, taking into account the different objectives of scientific school subjects, such as Physics, Chemistry and Natural History. *Seeing* would illuminate and guide the perceptions of hearing.

Nonetheless, based on the analysis of the documents, as well as on the manipulation of the instrumentation, it was confirmed that touch, although put into action as an operative and subsidiary sense, had an important role in scientific education, since the use of hands was present in all procedures in which instruments were used. The hypothesis that there is a hierarchy of senses put into view in class is, by itself, interesting and can yield future discussions.

Sources

Barbosa, R. (1950). *Obras completas de Rui Barbosa: lições de coisas* (Prefácio e revisão de Lourenço Filho). Rio de Janeiro, RJ: Ministério da Educação e Saúde.

Bellegarde, J. F. (1902). Um bom livro. *Revista de Ensino,* (1), 84-88.

Buisson, F. (1887). *Dictionnaire de pédagogie et d'instrucion primarie.* Paris, FR: Librarie Hachette. Disponível em: http://www.inrp.fr/edition-electronique/lodel/dictionnaire-ferdinand-buisson/document.php?id=3621

Ecole primaire superieure de La Ferte-Mace - Leçon de physique bobine de Ruhmkorff. (1900). (MNE Inv.: 1979.36669.340). Rouen, FR: Centre de Ressources et de Recherche du Musée National de l'Èducation.

Elementos de história natural segundo os programmas officiaes. Admissão a várias escolas superiores. Curso médio. (1917). (Coleção FTD). Rio de Janeiro, RJ: Francisco Alves.

Ganot, A. (1875). *Cours de physique*. Paris, FR: Chez L'auter Editeus.

Ganot, A. (1884). *Traité élémentaire de physique* (19a ed.). Paris, FR.

Hooker, J. D. (1894). *Botânica*. Rio de Janeiro, RJ: Laemmert & C. Editores Proprietários.

Huxley T. H. (1917). *Primeiras noções sobre as Sciências* (M. Ali Said, trad.). Rio de Janeiro, RJ: Francisco Alves.

Lamglebert, J. (1904). *Physica: curso elementar de estudos científicos*. Rio de Janeiro, RJ: Garnier.

Leçon de physique, École normale d'Evreux. (1900). (MNE Inv.: 1979.36669.0010). Rouen, FR: Centre de Ressources et de Recherche du Musée National de l'Èducation.

Lycee Fenelon de Lille. Salle de physique et chimie. (1905). (MNE Inv.: 1979.17243). Rouen, FR: Centre de Ressources et de Recherche du Musée National de l'Èducation.

Meirelles, Saturnino Soares. (1856). Lições elementares de physica segundo o programma de estudos do Collegio de Pedro II. Rio de Janeiro: Typographia Nacional.

Memorial do Colégio Marista Arquidiocesano de São Paulo. (1935). *Elucidário para a ficha de classificação: processo de equiparação definitiva*.

Milano, M. (1922). *Sciencias physicas e naturaes, hygiene*. São Paulo, SP: Monteiro Lobato.

Noções de sciencías physicas e naturaes. Physica e chimica ... Curso medio, programma de admissão a varias escolas superiores, por uma reunião de professores. (1927). Belo Horizonte, MG: Livraria Paulo de Azevedo e Cia.

Potsch, W. (1923). *História natural ou o Brasil e suas riquezas: algumas noções de higyene* (4a ed.). Rio de Janeiro, RJ: Oficinas Gráficas Villas Boas & Cia.

References

Bocchi, A. B. (2013). *A configuração de novos locais e práticas pedagógicas na escola: o museu escolar, os laboratórios e gabinetes de ensino do Colégio Marista Arquidiocesano de São Paulo (1908-1940)* (Mestrado em Educação). Pontifícia Universidade Católica de São Paulo, São Paulo.

Braghini, K. Z., Piñas, R. Q., & Pedro, R. T. (2014). Museu Escolar do Colégio Marista Arquidiocesano de São Paulo: constituição, histórico e primeiros movimentos de salvaguarda da coleção. *Revista Esboços, 21*(31), 28-49

Brenni, P. (2011). The evolution of teaching instruments and their use between 1800 and 1930. In P. Heering, & R. Wittje. *Learning by doing: experiments and instruments in the history of science teaching* (p. 281-316). Stuttgart, DE: Frans Steiner Verlag.

Brenni, P. (1997). Physics instruments ih the twentieth century. In J. Kriege, & D. Pestre (Ed.), *Science in the twenthieth century* (p. 742-759). Amsterdan, NL: Harwood Academic Publishers.

Broglie, L. A. (2010). *Deyrolle: leçons de choses* (Vol. 1). Paris: Michel Lafon.

Broglie, L. A. (2012). *Deyrolle: leçons de choses* (Vol. 2). Paris: Michel Lafon.

Crary, J. (1992). *Techniques of the observer: on vision and modernity in the nineteenth century*. Cambridge, MA: MIT Press.

Castel, J. S., Mocholí, C. S., & Sánchez, J. R. B. (2003). Instrumentos para la enseñanza: la colección de la Escuela Universitária de Magisterio. In J. R. B. Sánchez, & A. G. Belmar (Orgs.), *Abriendo lãs cajás negras* (p. 337-365, Colección de Instrumentos Científicos de la Universitat de Valencia). Valencia, ES: Bancaja.

Daston, L., & Galison, P. (2010). Epistemologies of the eye. In L. Daston, & P. Galison. *Objetivity* (p. 18-19). New York, NY: Zone Books.

Daston, L., & Lunbeck, E. (2011). *Histories of scientific observation*. Chicago, IL: The University of Chicago Press.

Heering, P. (2011). Tools for investigation, tools for instruction: potential transformations of instruments in the transfer from research to teaching. In P. Heering, & R. Wittje (Eds.), *Learning by doing, experiments and instruments in the history of science teaching* (p. 15-30). Stuttgart, DE: Franz Steiner Verlag.

Hulin, N. (2007). *L'enseignement secondaire scientifique en France d'un siègle à l'autre (1802-1980)*. Paris, FR: Institut National de Recherche Pédagogique.

Lehman, C., & Bensaude-Vincent, B. (2007). Public demonstrations of chemistry in eighteen century France. *Sciense & Education, 16*(6), 573-583.

Kremer, R. (2011). Reforming American Physics Pedagogy in the 1880s: Introducing 'Learnin by doing' via Student Laboratory Exercises'. In: P. Heering & R. Wittje (Ed.), *Learning by doing, experiments and instruments in the history of science teaching*. (p. 243-280). Stuttgart, DE: Franz Steiner Verlag.

Madi Filho, J. I. (2013). *Animais taxidermizados como materiais de ensino em fins do século XIX e começo do século XX* (Mestrado em Educação). Pontifícia Universidade de São Paulo, São Paulo.

Meloni, R. A. (2014). Patrimônio educativo na escola secundária: os objetos para a educação em ciências da natureza. In *Anais do X Congresso Luso-Brasileiro de História da Educação* (p. 1-12). Curitiba, PR.

Meneses, U. T. B. (2003). Fontes visuais, cultura visual, história visual: balanço provisório, propostas cautelares. *Revista Brasileira de História, 23*(45), 11-36.

Nieto-Galan, A. *Los públicos de la ciência: experts y profanos a través de la historia*. Madrid, ES: Marcial Pons Ediciones de Historia, 2011.

Pestre, D. (1996). Por uma nova história cultural e social das ciências: novas definições, novos objetos, novas abordagens. *Cadernos IG, 6*(1), 3-56.

Souza, R. F. (2007). História da cultura material escolar: um balanço inicial. In M. L. Bencostta (Org.), *Culturas escolares, saberes e práticas educativas: itinerários históricos* (p. 163-189). São Paulo, SP: Cortez.

Thesaurus de acervos científicos em Língua Portuguesa. (2016). Disponível em: http://thesaurusonline.museus.ul.pt/ficha.aspx?t=o&id=624

Turner, G. L'E. (1983). *Nineteenth-century scientific instruments*. Berkeley, CA: University of California Press, 1983.

Valdemarin, V. T. (2004). *Estudando as lições de coisas*. Campinas, SP: Autores Associados.

Van Helden, A., & Hankins, T. (1994). Introduction: instruments in the history of science. *Osiris, 9*, 1-6.

Vecchia, A., & Lorenz, K. (1998). *Programa de ensino da escola secundária brasileira: 1850-1951*. Curitiba, PR: Ed. do Autor.

Warnier, J.-P. (1999). *Construire la culture materielle. l'homme qui pensait avec ses doigts*. Paris, FR: Presses Universitaires de France.

Submetido em: 01/02/15
Aprovado em: 19/01/17