Tools for teaching Physics and Chemistry in secondary schools: The case of the *Colégio Culto à Ciência*, Brazil, 1899-1902

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Introduction

In the second half of the nineteenth century, the region of Campinas in the state of São Paulo had become one of the largest and most prosperous agriculture regions in Brazil. Large coffee plantations had already been transferred from the Paraíba Valley to Campinas due to the exhaustion of soil resources. Moreover, in Campinas both environmental conditions for coffee production and geographical conditions for trade and transport were better than in Paraíba. These conditions promoted the ascent of a wealthy social group, which had its feet in Brazil but eyes aiming at Europe and the United States. For many, the dream was to develop in Campinas a culturally civilized and economically liberal society. Words such as 'civilization' and 'progress' became frequent in speeches and exotic ideas, such as positivism, evolutionism and liberalism, stimulated change in the anxious minds. Conviction in the efficiency of liberalism inspired individual initiative and claims for social change, which began to materialise in the 1870s. Among them, perhaps the most significant due to their long-term impact were educational institutions that promoted innovative ideas both in terms of methods and contents. The *Colégio Florence*, the *Colégio Internacional* and the *Colégio Culto à Ciência* were examples of such institutions.[1] The latter will be the object of this chapter, today designated State School Culto à Ciência (*Escola Estadual Culto à Ciência, E. E. Culto à*

Ciência). Its origins and history will be briefly presented, followed by a discussion of a comparative study aimed at identifying and classifying its historical objects of chemistry and physics between 1899 and 1902.

The *Colégio Culto à Ciência*

Presently, the school's collection encompasses 209 historical objects from the nineteenth and twentieth centuries.[2] Between 1899 and 1902, the period under study, 103 objects were identified, studied and classified. In the following section, I will present and discuss this study and how it contributed to the preservation of the School's historical collections, particularly its scientific instruments.

The *Colégio Culto à Ciência* was founded in 1873 by a group of "farmers, tradesmen, military and intellectuals", who claimed to be "positivists, freemasons and republicans".[3] It operated under the administration of this group until 1892, when it was forced to close due to a combination of financial constraints and an epidemic of yellow fever in Campinas. In 1896, the school reopened as a public school and changed the name to Gymnasio de Campinas. From this point on, efforts were concentrated on making the *Gymnasio de Campinas* equivalent to the *Gymnasio Nacional* in Rio de Janeiro (formerly designated *Colégio Pedro II*) as equivalence would enable its students to pursuit higher education studies without further exams.[4]

The equivalence process required the adoption by the *Gymnasio* of syllabuses defined by the *Gymnasio Nacional*. It also required adaptation of the teaching infrastructure, particularly laboratories and cabinets.[5] In the case of Chemistry, for example, lessons should be "accompanied by practical work and systematic analytic essays through wet methods and pyrognostics".[6] During the 'equivalence' period, the discipline of Physics and Chemistry was integrated in the *Gymnasio*'s curriculum; a dedicated building was also constructed, followed by the acquisition of the necessary equipment.

Initial steps seem to have been taken by director Henrique Barcellos. In 1898, he acquired furniture for the first Physics Cabinet, Chemistry Laboratory and Natural History Museum;[7] he also initiated the construction of a new building for the Chemistry Laboratory.[8] The process took some years to complete. In 1901, a government tax officer confirmed that "the special Chemistry and Physics, Natural History and Anthropology classes were already prepared"[9] and, in 1902, that "the Physics Cabinet and Chemistry Laboratory were installed in a new building annex to the *Gymnasio*".[10]

Collections for Natural History teaching came from multiple institutions. Specimens came from the Ipiranga Museum (*Museu do Ipiranga*) in São Paulo and the School of Mines (*Escola de Minas*) in Ouro Preto, Minas Gerais. Letters asking for specimens were sent to the Botanical Garden (*Horto-botânico*) and

the Geographical and Geological Commission (*Comissão Geográfica e Geológica*) of the São Paulo state. The State Pharmaceutical Laboratory (*Laboratório Pharmaceutico do Estado*) was also asked for chemicals. It remains unknown how many of these requests had positive replies. The *Gymnasio* archives register donations of anatomy objects from the Group of Schools Jorge Tibiriça (*Grupo Escolar Jorge Tibiriça*),[11] materials from the *Escola Normal da Capital* and, in May 1902, a collection of minerals from the School of Mines of Ouro Preto.[12]

The *Gymnasio* had a close relation with the Agriculture Institute of Campinas (*Instituto Agronômico de Campinas*, IAC). The IAC, founded in 1887 and directed by an Austrian chemist named Franz W. Dafert (1863-1933), was located near the school (until recently). In the late nineteenth century, the IAC had considerable research outcomes and a modern infrastructure, both in terms of facilities – laboratories and experimental fields – and in terms of qualified technicians. The *Gymnasio* asked the IAC for a balance, hollow tubes (presumably in glass), distilled water and other materials.[13] The school also had public funds allocated by the state government. In April 1898, the first science teacher José Pinto de Moura prepared a budget for natural sciences teaching materials, most likely following a request from the school's board.

In the late nineteenth century and early twentieth century many objects were acquired by the *Gymnasio* to support the teaching of Chemistry, Physics and Natural History. These objects were listed in inventories produced by Eugenio Bulcão, the laboratory's coordinator. In 1899 and 1902,[14] 127 samples of chemical products and laboratory equipment were listed in large quantities, including 32 balloons, 22 funnels, 18 cylinders, 12 china capsules, 10 tweezers from Mahr, 9 glass crystallizers and 500 test tubes. The 1899 inventory listed 57 physics items and 46 chemistry items; in 1902, these corresponded to 185 and 102, respectively. Considering that in 1903 the school had 17 students enrolled in Chemistry and Physics, it seemed well equipped for daily teaching needs.

Presently, the school's collection encompasses 209 historical objects from the nineteenth and twentieth centuries. Between 1899 and 1902, the period under study, 103 objects were identified, studied and classified. In the following section, I will present and discuss this study, particularly its contribution to the preservation of the school's collection of scientific instruments.

Objects for science teaching

No longer used for teaching, scientific instruments were left forgotten in the school's laboratories for many years. Some were incomplete. In many cases, merely fragments survived. Physics instruments were unorganised, covered with dust and little associated information (including makers'

inscriptions), if any. Several had conservation problems, such as active oxidation and pests. The Chemistry collection of historical equipment was smaller. It comprised many glass and small items, which facilitated loss, damaged and probably theft.

The first objective was to perform emergency conservation and documentation actions. Objects were cleaned, labelled and photographed. In the laboratory, they were physically separated from instruments of everyday use. Then, the instrument identification and cataloguing task was initiated. It aimed at collecting, for each object, the following data: name, theme/area, acquisition date and maker (or supplier).

Methods used were mostly comparative. Apart from the objects themselves, the following sources were used: trade catalogues, collection catalogues from museums, teaching manuals and textbooks, and the school's archive, particularly the above mentioned 1899 and 1902 inventories. Although the study leaves many questions unanswered, it was possible to document a significant number of instruments.

The following online databases were consulted: the Virtual Museum of the Portuguese Ministry of Education[15] and the French ASEISTE's (*Association de Sauvegarde et d'Étude des Instruments Scientifiques et Techniques de l'Enseignment*).[16] Collections of scientific instruments visited included: in Portugal, the National Museum of Natural History and Science (University of Lisbon),[17] the Maynense Museum (Academy of Sciences of Lisbon), the secondary schools Gil Vicente and Passos Manuel (Lisbon), and the Science Museum (University of Coimbra); in Spain, the *Museu Pedagóxico de Galícia* (MUPEGA); in France, Deyrolle, the *Musée National de l'Éducation*, and its *Centre de Ressources et de Recherche* (Mont Saint Aignan, Rouen); in Germany, the Deutsches Museum; in Argentina, the *Colégio Nacional de Montserrat*, the *Biblioteca Mayor* of Córdoba University, and the *Museo Provincial de Ciencias Naturales*; finally, in Chile, the *Museo de la Educación Gabriela Mistral*. Although all institutions offered contributions to the Brazilian case, it is worth highlighting the easy access and insights gained at the National Museum of Natural History and Science of the University of Lisbon. Their rich archival sources, representative collection and standard cataloguing procedures were very useful for this study. It was possible to examine a vast number of instruments from the late 1880s to the early twentieth-century, as well as a comprehensive collection of trade catalogues from France and Germany.

After gathering the information abroad, a comparison with the school's inventories was made. Their examination revealed that many entries were

written casually, without great concern for rigor or precision – for example 'apparatus from bottom to top' (*aparelho de baixo para cima*). This suggests inventories were made for internal control and use, and were most likely located in the laboratories near the objects.

Collection description and object identification

As mentioned earlier, the number of historical scientific instruments currently at the *E.E. Culto à Ciência* is 209. The historical inventories from the school's archives date from 1899 to 1970. Examination of these enabled the following preliminary identification and classification: 122 were identified as Physics instruments (*apparelhos de physica*) and 70 as Chemistry instruments and equipment (*apparelhos de chimica*) (Table 1); 17 could not be identified, let alone classified.[18]

Table 1 - Preliminary classification of instruments found in the *E. E. Colégio Culto à Ciência* today after cross-examination with the school's historical inventories, the first from 1899 and the last from 1970. The French original classification was maintained.

Themes/Areas	Quantities
Pesanteur	8
Hydrostatique et propriétés des gaz	17
Chaleur	12
Electricité statique	17
Magnétisme et Électricité dynamique	47
Acoustique	7
Optique	14
Total	**122**

Next, this group was further examined enabling the identification of 103 objects existing today that were mentioned in the 1899 and 1902 inventories: 77 from physics and 26 from chemistry. Examination was done through maker's inscriptions, similarity and plausibility. Needless to say that correspondence between a catalogue entry and a real object is considerably difficult to establish with certainty, however the preliminary 'working' correspondence achieved allowed progress in historical analysis and collection preservation. It should be mentioned that no other documentation has been found so far in the school's archives (invoices, old numbers, receipts, etc.).[19]

Many physics instruments bear the inscription 'Les Fils d'Emile Deyrolle' and their identification was based on their 1898 catalogue.[20] Moreover, a total of 89 physics instruments coincide in the schools historical inventories and in the Deyrolle 1898 catalogue.[21] Although it was a common instrument maker in primary, secondary and higher education worldwide at the time, the school's archives offer no indication for the preference.

Many objects existing today only occur in the 1899 and 1902 inventories and not after; therefore, it is plausible to admit they were acquired before 1902. This is the case, for example, of the Kipp's apparatuses – also designated Kipp's generator – among several others, both from chemistry and physics. Other examples are the projection galvanometer (Fig. 1), the electrolysis U-tube (Fig. 2) and the Kinnersley's thermometer (Fig. 3).

Fig. 1 - Projection galvanometer, *E.E. Culto à Ciência* collection (photo: R. A. Meloni).

Fig. 2 - Electrolysis U-tube, *E.E. Culto à Ciência* collection (photo: R. A. Meloni).

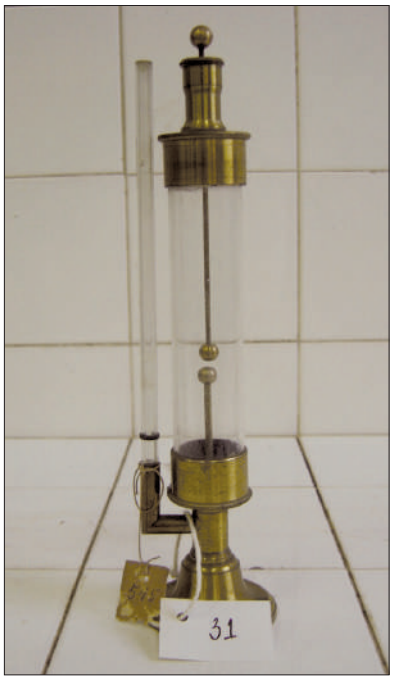

Fig. 3 - Kinnersley's thermometer, *E.E. Culto à Ciência* collection (photo: R. A. Meloni).

As is often the case with chemistry equipment, the number of objects with makers' inscriptions in the *E. E. Culto à Ciência* collection is scarce. Although further research needs to be made, the majority was probably not from Deyrolle. In 1914, Deyrolle offered five types of *Cabinets de Chimie*,[22] with different prices and number of objects (e.g. Cabinet 3 had c. 140 objects). The school's 1899 inventory lists 46 chemistry objects and the 1902 inventory lists 46 chemistry objects. Of these, only 10 entries coincide in the Deyrolle catalogue.[23] Moreover, the school's inventories list equipment that was not commercialised by the French maker, namely the stove, the boiler, Gay-Lussac's alcoholmeter, the automatic pipette, metal burette, Mohr's burette, the instrument to "determine the carbon dioxide gas according to Vanderberghe",[24] idem according to Liebig, a Berzelius's gasometer, a spectroscope and the "precision scales for chemical analyses, sensitivity 10 mg".[25]

Some objects from the chemistry collection bear the inscription of the maker E. Adnet, Paris. This is the case of the chamber depicted in Fig. 4, as well as several utensils such as beakers and china capsules. Entries in the historical inventories also refer to Kipp's apparatus, Will and Warrentrap tubes, equipment for the study of heat exchange in chemical reactions, e.g.

thermometers, one thermametrograph of Kappeller [(sic), original reads *thermametrographo de Kappeler*] and Hehner colorimeters (*colorímetros de Hehner*). These cannot be found in the collection today.

Fig. 4 - Chamber by Adnet, E. E. Culto à Ciência collection (photo: R. A. Meloni).

Many of the materials and equipment found in the school's inventories could also be found in catalogues of German makers. Two catalogues in particular were examined: Cornelius Heinz (Aachen, 1907)[26] and Dr. Robert Muencke (Berlin, 1910).[27] The results are presented in Table 2.

Table 2 - Cross-examination of two German makers' trade catalogues and the *E. E. Culto à Ciência* historical inventories.

Cornelius Heinz	Dr. Robert Muencke
Gooch crucible, made of china *Kipp apparatuses* *U-shaped tube for electrolysis, named after A-W. Hoffmann* [*"cadinho Gooch made of china and with a cap"*, "*apparelhos de Kipp*", "*tubo em U para eletrólise chamado de A. W. Hofmann*"]	*Fletscher aspirator* *Berzelius gasometer* *Hehner calorimeters* *Dreschel flasks* *Sartorius scales* *Varrentrap and Will tube* *Kipp apparatuses* *Mohr burette* *Gay-Lussac alcohometer* [*"aspirador Fletscher, gazometro de Berzélius, the calorímetros Hehner, frascos de Drechsel, balança de Sartorius, tubo de Varrentrap und Will, apparelhos de Kipp, buretas de Mohr and the alcoômetro de Gay-Lussac"*].

Other designations appear to be associated with entries in the school's inventories, such as "*caldeira de Soxhlet, estufa de Rüdoff, estufa de Liebig, discadores de Fresenius, suporte para buretas segundo Allihn.*"[28] Finally, the inventories list a certain type of automatic pipette, which is associated with the name Dafert in Dr. Muencke's catalogue. Further research is required, but the coincidence with the name of the Austrian chemist Franz Dafert, founder of the Agriculture Institute of Campinas (*Instituto Agronômico de Campinas*, IAC) in the late nineteenth century cannot pass unnoticed.

Concluding remarks

The preliminary study of the scientific instruments' collection of the *E. E. Culto à Ciência* in Campinas, São Paulo, provided interesting insights into the cabinets of Physics and Chemistry in Brazilian secondary schools in the late nineteenth and early twentieth century, particularly as a result of the efforts to meet the requirements of the *Gimnasio Nacional*. Many schools created laboratories and acquired a considerable number of scientific instruments, materials and equipment to achieve equivalence to the *Gimnasio* in Rio and grant their students direct access to higher education.

As a consequence of this encouragement, the *E.E. Culto à Ciência* adapted their facilities, organised museums, laboratories and dedicated rooms for the teaching of science and imported equipment, mainly from Europe. Using the physics and chemistry instruments surviving today as a point of departure, a comparative study was done for the period 1899 to 1902, through historical sources (school's inventories, trade catalogues) and reference collections in several institutions in South America and Europe. The study suggests that the school was well equipped for teaching chemistry and physics and their facilities comprised a comprehensive number of objects that could support coverage of the syllabuses requirements. The study also suggests that many of the instruments acquired no longer exist. This is likely to result from loss, damage, obsolescence, and removal of associated contents from the syllabuses, among other reasons.

Many questions remain unanswered, however, and require further research into the pedagogical practices: were the instruments really used by students or were they merely operated by teachers in demonstrations? In which contexts of experimental teaching were they used? Did they suffer local adaptation, e.g. cannibalisation, local innovation?

In terms of cultural heritage of science and technology in Brazil, the study also contributed to providing contemporary meaning to these objects, a task that continues today.

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Notes

[1] M. L. S. Hilsdorf, História da Educação Brasileira: leituras, Thomson Learning Edições, São Paulo, 2006.

[2] See an overview of the cultural heritage of the E. E. Culto à Ciência in a video by the Secretary of Education, State of São Paulo: http://www.youtube.com/watch?v=vZWhfu9mM0o, accessed 7 July 2014.

[3] C. S. V. Moraes, O Ideário Republicano e a Educação, Mercado de Letras, Campinas, 2006, p.15.

[4] See Granato and Santos, Zancul and Barreto, and also Braghini, in this volume.

[5] Brazil, Decree No. 3890, 1 January, 1901. Code of the Institutos Officiaes de Ensino Superior e Secundário.

[6] A. Vechia and K. M. Lorenz, Programa de Ensino da escola secundária brasileira – 1850/1951, author's edition, Curitiba, 1998, p. 177.

[7] Correspondence to the Internal Affairs Secretary, No.7. Archives of the E.E. Culto à Ciência.

[8] Idem, No. 39.

[9] Brazil. Report of the Government tax officer Antonio Alvares Lobo, 15 February 1901.

[10] Idem, 8 October 1902.

[11] Correspondence to the Internal Affairs Secretary, No. 24. Archives of the E.E. Culto à Ciência.

[12] Correspondence 1898-1903. Archives of the E.E. Culto à Ciência.

[13] Idem.

[14] List of the Chemical Apparatuses and Products existing in the “Laboratory” (from 1899 onwards). Archives of the E.E. Culto à Ciência.

[15] Museu Virtual do Ministério da Educação de Portugal; its website seems to have been meanwhile discontinued.

[16] See http://www.aseiste.org/, accessed: 7 July 2014.

[17] Then designated Museum of Science of the University of Lisbon. I am especially grateful to Dr. Marta Lourenço, chief curator and deputy director of the Museum.

[18] List of the Chemical Apparatuses and Products existing in the “Laboratory” (from 1899 onwards). Archives of the E.E. Culto à Ciência.

[19] This research is still ongoing, with the support of Dr. Marcus Granato, from the MAST in Rio de Janeiro and FAPESP.

[20] Catalogue de Physique, Les Fils D'Émille Deyrolle, février 1898. Archives of the

National Museum of Natural History and Science, University of Lisbon.

[21] Idem.

[22] Catalogue Méthodique. Matériel de Laboratoire, Les Fils d'Émile Deyrolle, 1914. Archives of Maison Deyrolle.

[23] Coincidence is in type and not literal. For example, the school's inventories say “Pipettes with marks 1cc, 2cc, 5cc, 10cc, 20cc, 25cc, 50cc, 1000cc (one of each)” whereas Deyrolle's catalogue merely refers to “2 Pipettes”.

[24] The designations of Chemistry objects have been transcribed exactly as they are found in the inventories.

[25] Deyrolle's catalogue offered one Roberval's scales, with inferior sensitivity.

[26] Cornelius Heins, Preis-Verzeichnis. Cornelius Heins Fabrik und Lager, Aachen, 1907. Archives of the National Museum of Natural History and Science, University of Lisbon.

[27] Dr. Rob. Muencke, Haupt-Preisliste N°63, Über Allgemeine chemische Laboratoriums. Apparate und Gerätschaften von Dr. Rob. Muencke, Berlin, 1910. Archives of the National Museum of Natural History and Science, University of Lisbon.

[28] Designations were kept in Portuguese as doubts remain regarding the transcription.