2015

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During the 1800s foreign curriculum models and teaching methodologies shaped the course of the debates and policy decisions on basic education in Brazil. The impact was most apparent in secondary education where French pedagogical theories and practices influenced the curriculum, syllabi and textbooks of the most prestigious institution in Brazil, the College Pedro II. The Imperial Government established the college in the Municipality of Rio de Janeiro in 1838 to tend to the children of the functionaries and nobles of the Court, and to serve as a model for public and private secondary schools functioning throughout the country. During the 1800s the central government legislated the purpose, content and organization of the College Pedro II, always with an eye on indirectly influencing secondary education that, because of the Constitution of 1824 and the Additional Act of 1834, was the exclusive responsibility of the provinces (Lorenz, 2004).

With the founding of the Republic in 1889, the provisional government sought to reform the program of studies of the college, renamed the National Gymnasium, to eliminate vestiges of the Empire and introduce a modern and scientific education. For this, guidance and substance were drawn from Auguste Comte's positivist philosophy and his concept of a Rational Scientific Education. This paper examines Comte's positivist conceptual framework and its expression in the Brazilian secondary curriculum in the final decade of the nineteenth century.

Positivism

Auguste Comte (1798–1857) was the founder of positivism, a philosophical and political ideology introduced in France in the first half of the nineteenth century and widely disseminated in the second half of the century. Comte sought to improve intellectual, moral and political institutions by abandoning theological and metaphysical interpretations of Nature and Man, which were regarded as inadequate and imperfect knowledge, and in adopting a scientific approach to understanding observed phenomena. He organized his ideas under the rubric "positivism," because it referred to the reality-oriented and constructive tendency of his theoretical system. Positivism in its broadest sense was a system of philosophy that was grounded in experience and empirical knowledge of natural phenomena.

Basic positivist doctrines were published by Comte between 1830 and 1842 in his six-volume work, the *Cours de philosophie positive,* and in 1848 in the *Discours sur l'ensemble du positivisme.* Comte's political and religious philosophy was divulged in his *Discours sur l'esprit*

positif (1844), and between 1851 and 1854 in the four volumes of the *Système de politique positive, ou traité de sociologie instituant la religion de l'Humanité.* In these capacious works, Comte promoted a religious system that "denies the existence of a personal God and takes humanity, 'the great being', as the object of its veneration and cult" (Sauvage, 1911).

In the first three volumes of the *Course on Positive Philosophy,* Comte discusses the sciences of Mathematics, Astronomy, Physics, Chemistry and Biology, and in the latter volumes Sociology. In this monumental work, Comte presented his ideas on the natural sciences in 72 lessons. Fundamental to the positivist doctrine was the distinction that Comte drew between natural philosophy and the empirical sciences. The philosophical system proposed in his early works a priori dismissed metaphysical speculation as the starting point of knowledge, rejected the "existence of final causes" and the "knowableness of the absolute," and in its stead maintained that only sensory data are the grounding substance of human knowledge (Sauvage, 1911).

Comte's writings on the natural sciences advances several theses. Among these is his concept on social evolution, which is articulated in "The Law of Human Progress" or "The Law of Three Stages." As stated by Comte: "each of our leading conceptions, each branch of our knowledge, passes successively through three different theoretical conditions: the Theological, or fictitious; the Metaphysical, or abstract; and the Scientific, or positive."

Comte's second best known theory is intimately connected to the Law of Three Stages. His "Law of Classification" was a singular contribution because of its unique depiction of the organization and evolution of the six "positive" sciences: mathematics, astronomy, physics, chemistry, biology and sociology. Comte argued that theses sciences sought to discover the laws that govern natural phenomena and that they could be hierarchically classified based on their degree of "positivity," that is, the degree of complexity of the natural phenomena they investigated. This hierarchy implies that descriptions and explanations of phenomena become increasingly more abstract as generalizations, organizing principles and paradigms are formulated to explain and predict increasingly complex natural occurrences. Hence, Comte considered these as "Abstract Sciences" to distinguish them from "Concrete Sciences" that eschew theorization and rely primarily on observation.

Comte viewed the hierarchy as not only a logical construct, but also as a developmental phenomenon. Over time, the sciences appear appeared in man's history in a sequence that mirrored the hierarchy. As will be shown, The Law of Classification was incorporated in the secondary education reforms in late nineteenth-century Brazil.

Positivism in Brazil

Of all of the countries of Lain America, none embraced Positivism with more enthusiasm than Brazil. The extent of the positivist influence on Brazilian social institutions is illustrated by the motto emblazoned on the Brazilian flag, "*Ordem e Progresso"* (Order and Progress), which was inspired by Comte's positivist slogan, "*L'amour pour principe et l'ordre pour base; le progrès pour but"* ("Love as a principle and order as the basis; Progress as the goal"). The flag, designed

by a cabal of avid positivists, was first unfurled after a military coup d'état deposed the monarchy and proclaimed Brazil a republic in 1889.

Social and intellectual elites found in Positivism an ideology that resonated with their interest in modernizing Brazil. Reference to Comte and his positivist doctrines were introduced in the 1840s and appeared with increasing frequency up to the end of the century. Positivist thought was disseminated in journals, through advocacy groups, in classrooms and theses the Faculties of Medicine and the Military Schools in Bahia, Rio de Janeiro and Porto Alegre (the capital of the far southern state of Rio Grande do Sul); and in the engineering courses of the Central School, later transformed into the Polytechnic School in 1874, in the Municipality of the Court.

Historians have portrayed the influence of positivism on Brazilian society, culture and institutions in a variety of ways. For some, Comte's writings provided a political rationale for creating a Republic to replace the Empire. For others, Comteism challenged established religion, targeting Catholicism, and in its place promoted a "Religion of Humanity." For many, positivism's empirical focus forged a new scientific worldview that replaced the beliefs of the classical/humanistic tradition suffused throughout Brazilian culture. It was a philosophy right for its time, as it eased Brazilian intellectuals away from speculation and towards scientific empiricism based on the positivist methodologies of observation, experimentation and categorization. For some, Comte's early writings and advocacy of a rational scientific education provided a conceptual framework for reorganizing the programs of studies of select superior and secondary institutions. The most renowned and influential member of this cadre of professionals was Benjamin Constant Botelho de Magalhães (1833 - 1891).

Benjamin Constant is recognized as the foremost figure in the positivist movement and is identified as "Founder of the Republic." Constant was a military man who had obtained a bachelor's degree in the physical and mathematical sciences. He had worked as mathematics examiner of candidates for superior courses in the empire, a teacher and director of the Institute for the Blind, and in the 1870s as a lecturer of mathematics at the Military School in Rio de Janeiro and at the Imperial College Pedro II. He also founded the Brazilian Positivist Society. From 1881 to 1889 Constant introduced his cadets to Comtean Positivism, which he had encountered in 1857 when reading the *Course of Positive Philosophy*. Constant view of the teaching of mathematics was that it promoted the positivist philosophy and in so doing created a new military caste that viewed positivism as the means for realizing their goals of order and progress (da Silva, 1999, p. 331-334).

Constant's platform in the Military School and his popularity with the young politicized members of the officer corps thrust him to the forefront of liberal efforts to form a Republic. When this was accomplished in 1889 he was after named head of the Ministry of Public Instruction and Communication. His tenure, however, was short-lived since he passed away two years later.

Constant, nevertheless, did create several educational institutions, initiated a reform of the Military School in Rio de Janeiro and, most significantly in this narrative, developed a positivist-inspired blueprint for the secondary education curriculum of the National Gymnasium (formerly the Imperial College Pedro II), the model public institution supported by the central government

since 1837. His new curriculum was divulged in 1890, and served as the substrate for subsequent reforms in 1892, 1894 and 1898 (Lorenz, 2010).

Rational Scientific Education

Of the many takes on Positivism, none is more significant than that of Benjamin Constant who extracted from the *Cours de philosophie positive* an organizing principle for the program of studies of the National Gymnasium. During the Empire, the content and organization of classical/humanistic and scientific studies in the college lacked a conceptual framework. Since its inception in 1837, there was no encompassing vision that coherently dictated the vertical and lateral dimensions of the curriculum. Courses were assigned to grade levels based on prior practices or expediency, as in 1855 when science courses were moved up in the curricular sequence to accommodate students who could opt to complete their secondary studies early in anticipation of embarking on technical careers. In contradistinction, Constant adopted Comte's hierarchy of scientific knowledge as the organizational model for the secondary curriculum. The sciences would be taught along with language and humanities courses. Constant's reform was a unique attempt to impose a logical order on the studies of the National Gymnasium.

At the heart of Constant's curriculum model was the notion of the hierarchical nature of positivist knowledge and method in the sciences. And surely Constant's commitment to reform followed Comte's exhortation to institute a "Rational Scientific Education" based on positive principles. A Rational Scientific Education, from Comte's perspective, advocates the pursuit of fundamental knowledge through the six abstract sciences. Comte writes: "The most interesting property of our formula of gradation is its effect on education, both general and scientific. . . It will be more and more evident as we proceed, that no science can be effectually pursued without the preparation of a competent knowledge of the anterior sciences on which it depends. Physical philosophers cannot understand Physics without at least a general knowledge of Astronomy; nor Chemists, without Physics and Astronomy; nor Physiologists, without Chemistry, Physics, and Astronomy; nor, above all, the students of Social philosophy, without a general knowledge of all the anterior sciences. . . Our intellectual system cannot be renovated till the natural sciences are studied in their proper order" (Comte, 1855). Herein lies the organizing principle for Constant's new curriculum.

In Decree no. 981 of November 8, 1890, Constant reorganized the 7-year curriculum of the National Gymnasium according to the Comtean hierarchy. To support the program, he created the chair of Astronomy and Mechanics, introduced the study of Calculus and Sociology, and indicates positivist textooks in the syllabi. In Constant's curriculum, shown below, the study of mathematics was given great emphasis, being concentrated in the first three years of study and reviewed in the next four years. Courses in the natural sciences followed in years four to seven (Brazil, 1962).

1st year: Arithmetic and Elementary Algebra

2nd year: Preliminary Geometry, Rectilinear Trigonometry, Spatial Geometry

3rd year: General Geometry and its Algebraic Compliment
Differential and Integral Calculus, Descriptive Geometry

4th year: Mechanics and Astronomy

5th year: Physics and Chemistry

6th year: Biology

7th year: Sociology and Moral

Constant curriculum blueprint embodied Comte's concept of a rational scientific education. To appreciate the fidelity with which Constant adhered to the Comtean vision, we will briefly examine Comte's logic when sequencing the sciences that appeared in the new curriculum of the National Gymnasium.

The Positivist Sciences

Comte's considered the positivist sciences to be "abstract" because of their concern with establishing principles and rules, rather than with describing natural phenomena. This latter task fell into the domain of the "concrete sciences," such as mineralogy, zoology and botany. These sciences unearthed facts that the abstract sciences could access to formulate theories and to discover natural laws. As noted, "In Comte's scheme the concrete sciences were not unimportant – they provided facts which aided the positive sciences – but they were both basic and essential and thus could not be the source of fundamental principles of human knowledge" (McCormick, 1976, p. 38).

In Comte's view, then, there were five abstract sciences of successive dependence; Astronomy, Physics Chemistry, Physiology and Sociology. These sciences were preceded by and grounded in logical and practical mathematics.

Mathematics

Comte asserted that Mathematics was the first and most powerful instrument that the human spirit could employ when investigating the laws of natural phenomena. In his words, "It follows that the study of them is an indispensable preliminary to that of all others. Therefore, Mathematics must hold the first place in the hierarchy of the sciences, and be the point of departure of all Education, whether general or special" (Comte, 1855).

In arguing this point, Comte divided Mathematics in two parts: "Abstract Mathematics" or the Calculus, which depends only on reasoning powers and inherent logic; and "Concrete

Mathematics" -- comprised of General Geometry and Rational Mechanics – which relies on the sensory input when making observations and measurements of simple phenomena. In the positivist hierarchy, Geometry and Rational Mechanics constitute a true starting point for the natural sciences: indeed, "all the phenomena of the universe may be regarded, as far as possible, as geometrical or mechanical." When considering both branches of mathematics, the Concrete is the basis of the abstract.

In the Constant curriculum, arithmetic, algebra, basics of geometry and trigonometry were taught in the first and second years of study. The basic content and position of these courses in the program varied little from curricula prior to the Constant reform. An analysis of these courses shows that there was no defining characteristic of their mathematics content that ostensibly made it "positivist" (Valente, 2007).

Comte's positivist mathematics, however, was introduced in the 3rd year with the study of Differential and Integral Calculus and General Geometry. The textbooks adopted were the *Premiers éléments de calcul infinitésimal* (1889, 1897) of Michel Louis Hippolyte Sonnet and the *Elementos de Geometria Descriptiva* (s.d.) translated from the French by Eugenio de Barros Raja Gabaglia, director of the National Gymnasium, and originally published by the French Christian Brothers.

Mechanics and Astronomy

Comte created a chair of Astronomy and Mechanics and scheduled both disciplines to be taught three time per week in the 4th year of the curriculum. In the curricular sequence, however, Mechanics preceded Astronomy.

Mechanics

For Comte, Rational Mechanics bridged the gap between abstract mathematics and he abstract science of astronomy. This science presented a mathematical system for describing the movement of celestial bodies and the operation of the Keplerian laws and thus acted as a prelude to the study of astronomy. Rational Mechanics was scheduled to be taught after Geometry and Calculus, yet before Astronomy, in the 4th year of the program.

The textbook adopted for the course was *Mecânica Geral*, authored by José Eulálio da Silva Oliveira, professor of Applied Mechanics of the Superior War College. The text followed Comte's representation of the subject and was subsequently praised by Georges Audiffrent (1823-1909) in *Notice sur la vie et la doctrine d'Auguste Comte* (1894) for adhering to positivist doctrine. Silva Oliveira remarks that he organized the content of his text according to "the subjective and didactic divisions of general mechanics" proposed by Comte. He thus identified the two major areas of study of mechanics: the first called Statics since the time of Archimedes, and the second known as Dynamics since the time of Galileo or d'Alembert (Silva Oliveira, 1895, p. 15).

Dynamics was further subdivided into Hydrostatics and Hydrodynamics. The syllabus of the course represented followed this schema.

Astronomy

Comte outlined his philosophical position on Astronomy in some 400 pages of *La philosophie astronomique et la philosophie de la physique*, the second volume of the *Cours.* For Comte, Astronomy appears after Mathematics and is the first of the natural sciences to reach the positive stage. The phenomena that it investigates are simple and remote, and inquiry is based exclusively on the single sense of sight. Because it relies primarily on the measurement of forms, distances, magnitudes and movements, astronomical questions are ultimately questions of geometry or mechanics. (Lewes, 1852, p. 81).

Positivist Astronomy covers two areas of inquiry that increase in complexity: (1) Geometrical Astronomy, or Celestial Geometry, that studies the forms and magnitudes of the heavenly bodies, and the general rules governing changes in their positions, and (2) Celestial Mechanics, that investigates the actual movements of the celestial bodies according to concepts of rational mechanics.

Astronomy appeared in the college's curriculum from 1895 to 1898. The textbook that was adopted was the second edition of Comte's own *Traité philosophique d'astronomie populaire, précéde du Discours sur l'espirit positif,* first published 1843 and corrected and published in *1893 by the* Apostola Postiviste du Brésil. (Lorenz, 2010). In the syllabus of the course, the professor responsible, Alfredo Coelho Barreto, indicated that he would faithfully follow the content prescribed in Comte's text (Vechia & Lorenz, 1998, p. 153).

While astronomy is an "applied" mathematical science, it is also a link between general mechanics and terrestrial physics. Because of the calculations of mechanics, the bond between astronomy and physics is established (Lewes,1852, p. 85).

Physics and Chemistry

Comte divided all natural phenomena into inorganic and organic, with the second category including more complex and less general phenomena than the first. Inorganic phenomena should therefore be studied before organic phenomena, since the concepts of the first are necessary to proceed in the study of the second. The sciences of physics and chemistry investigate these two types of phenomena. Comte discusses these sciences in volumes two and three of the *Cours de philosophie positive*.

Courses in Physics and Chemistry were designated for the 5^{th} year of the Constant curriculum, and as with the previous two sciences, the study of physics, conceptually, was to precede the study of chemistry. How these two sciences were actually scheduled in the curriculum is unclear.

Physics

Positivist Physics follows Astronomy and is the second of the fundamental sciences. A feature that distinguishes physics from astronomy is that in its investigations physics may modify natural phenomena through experimentation, whereas astronomy restricts itself to the observation of the phenomena. Comte discusses the nature of Physics in the second volume of the *Cours* titled *La philosophie astronomique et la philosophie de la physique* (1835).

Comte viewed "physics" in a broad sense as the study of both inorganic and organic phenomena. More specifically, he subdivided this area of study into "celestial physics" which is equated with celestial astronomy; "terrestrial physics", which embraces concepts of mechanics and chemistry; and "organic physics", which deals with the laws of nature and the laws governing human society. This last area of study Comte labeled "Social Physics," which he later renamed "Sociology" (Comte, 1905, p. 29).

The most basic level of Terrestrial Physics -- which is properly called "physics" -- focuses on the description of the properties and mechanical characteristics of inorganic objects. Comte thus defines physics as the study of "the laws which govern the general properties of bodies ordinarily viewed in their masses, and constantly places in circumstances capable of maintaining intact the composition of their molecules, and most frequently even their state of aggregation." (Lewes, 1852, p. 97). Like other abstract sciences, he divided physics into branches, based on their increasing complexity. He identifies barology (study of weight and gravity), thermology (study of heat), acoustics, optics, and electrical phenomena, in this order.

Chemistry

In the Comtean scheme, Chemistry is the second sub-division of terrestrial physics. Because Chemistry is a more complex science than physics it follows the latter in the Comtean hierarchy. Historically, the study of the general physical characteristics of objects -- such as their weight, thermal and acoustic characteristics, etc,, -- preceded investigations into their molecular properties. Logically, physics deals with large masses and their phenomena, whereas chemistry deals with the constituents of large masses – that is, minute masses (molecules) and their derived phenomena.

Comte maintained that chemistry was of great use to biology since its discoveries and methods of observation and experimentation could be used to explain physiological phenomena. The fundamental physiological processes that lead to the composition and decomposition of substances, for example are essentially chemical in nature. Thus, in the logic of the positivist hierarchy, Chemistry is related to but precedes Biology. This horizontal and vertical relationship is discussed and reflected in the tile of the third volume of the *Cours*, *La philosophie chimique et la philosophie biologique* (1838).

Biology

In the third volume of the *Cours* Comte presented his thoughts on the nature of Biology. The term "Biology" was introduced in 1802 in Germany by Gottfried Reinhold Treviranus (1776-1837) and in France by Jean Baptiste Lamarck (1744-1829). Both scientists characterized this new science as the general study of living organisms for the purpose of identifying natural laws that govern their structure and functioning. Both scientists distinguished Biology from Botany and Zoology which focus primarily on the description and classification of flora and fauna. Biology, for its part, bases its generalizations and derives natural laws from the *materia prima* of these two sciences (Lorenz, 2010). Comte embraced this viewpoint in *La philosophie chimique et la philosophie biologique* (1838), the third volume of his Positive Course. He also outlined a succinct program of study in biology in the "Traité de Biologie," which appeared in the fourth volume of the *Système de politique positive* (1851-1854).

In the positivist hierarchy, Biology is an abstract science that evolves from the descriptive and classificatory studies of natural history. As part of this evolution, the study of plant and animal anatomy gave rise to the detailed study of their internal workings. Physics elucidated the effects of environmental factors such as heat, light, gravity and electricity on organisms and their relationship with the environment. Chemistry revealed how molecular structures and transformations, affected the structures and internal functioning of organisms. Hence, "by Comte's time, physiology had come to occupy a place of importance in biological research at least equal to that of natural history" (McCormick, 1976, p. 72-73).

Because Comte used the term "biology" to refer to physiological phenomena, debates about the appropriateness of this term in the Comtean hierarchy ensued . Even Charles Robin and Emile Littré, two of Comte's greatest disciples, were not in agreement on the proper definition. Although proposed by Constant in the 1890 reformulation of curriculum of the National Gymnasium, Biology as an autonomous discipline was first introduced in the curriculum of the college in 1898. Nevertheless, it has been deduced that Biology as conceived by Comte was taught in botany and zoology courses well into the first years of the twentieth century.

The content taught in these courses by professor Rodolfo Paula Lopes, an avowed positivist, was outlined later in his textbook, *Elementos de Biologia*, which was published in 1911. The content of his textbook is aligned with that of the *Plan d'un cours de biologie d'après Auguste Comte* (1883) of Pierre Laffitte (Lorenz, 2010)

Sociology

The Constant curriculum scheduled the study of sociology in the 7th and final year of study in the National Gymnasium. The positivist doctrine that underpinned this curriculum represented sociology as the culminating study of the positive sciences that had begun with rational mechanics in the third year of the program of study.

Comte viewed the evolution of knowledge of the physical world as a progression from the simple to the complex, with knowledge about Man, the most complex phenomenon of all, being

the apex. In this trajectory, "social physics," or "sociology" as he later termed it as the greatest and last of the positive sciences. In the Comtean hierarchy and understanding of man and society is dependent first upon understanding the positivist sciences that precede it. One cannot speak about social phenomena without first understanding the biology of organisms, which in turn is dependent upon the physical and chemical properties they exhibit

Comte defined the Sociology as the science that discovers the laws of human society. These laws, which resembled the laws of nature, can be discovered by applying the methods of inquiry of the natural sciences. He divided Sociology into Social Statics, which investigates the inter-relations of major social institutions such as the family and economic and political entities; and Social Dynamics examines societies as a whole. Taking society as the unit of analysis, social inquiry seeks to determine how societies change through time and make progress towards a state of perfection.

Effects of the Constant Reform

Constant issued his reform in 1890 and it immediately drew criticism. Objections were raised about the mathematics courses, which many felt were to demanding for young students. Since students could enroll in the college when they were 7 or 8 years old, the front-loaded mathematics sequence would be beyond their capacity. Regardless, the direction of the curriculum was defined, and the course sequence endured throughout the rest of the century.

Constant's curriculum was not immediately implemented in 1890. It took a number of years before the courses, especially in the sciences, were gradually introduced as they replaced the courses of the previous curriculum. While Comte's positivist courses were evidenced partially in the National Gymnasium throughout the decade of 1890, all of the courses were taught from 1894 to 1901, a period spanning three subsequent reformulations of the curriculum. During this period, works directly reflecting Comtean interpretations of certain sciences were adopted in the College.

The long term effect of the reform was that three sciences of mechanics, astronomy and Biology became permanent parts of the curriculum, at least until the final of the decade. Furthermore, the general sequence of mathematics and science courses was maintained. While there was some variation, especially in the reform of 1892 of Fernando Lobo, the 1894 curriculum of Cassiano do Nascimento, clearly maintained the order of mathematics, mechanics and astronomy, physics and chemistry, and finally Biology. Constant's reform may have been short-lived, but vestiges endured until the end of the century and to a lesser extent in the early part of the twentieth century.

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