Beyond Borders

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Fresh Perspectives in History of Science

Edited by

Josep Simon and Néstor Herran
with Tayra Lanuza-Navarro, Pedro Ruiz-Castell
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THE FRANCO-BRITISH COMMUNICATION AND APPROPRIATION OF GANOT'S *PHYSIQUE* (1851-1881)

JOSEP SIMON

In 1851, Adolphe Ganot (1804-1887) published in Paris his *Traité élémentaire de physique expérimentale et appliquée*.[1] The book was the result of twenty years' experience in a science-teaching career, first as a student at the École Normale,[2] then as a teacher in a French provincial *collège*, and finally in a private school in Paris.[3] The *Traité* met with rapid success, running through eight editions in eight years. In 1859, he published another textbook, the *Cours de physique purement expérimentale*, intended for a different readership.[4] Ganot produced successive editions of his two books until 1881, when he handed them over through contract to Hachette, the leading French publisher of secondary school textbooks. According to Ganot, the last editions of the *Traité* (18th, 1880) and of the *Cours* (8th, 1881), that he prepared himself, had print runs of 20,000 and 13,000 copies, respectively.[5] By then he claimed to have produced 204,000 copies of the former (since 1851), and 64,500 copies of the latter (since 1859).[6]

Furthermore, in this period, the *Traité* was translated into Italian (1852), Spanish (1856), Dutch (1856), German (1858), Swedish (1857-60), Spanish (Paris, 1860), English (1861-3), Polish (1865), Bulgarian (1869), and Turkish (1876). The *Cours* was translated into English (New York, 1860), Dutch (1862), Italian (1868), English (1872) and Spanish (1873).[7] Although the translation of French physics textbooks into other languages was common in this period,[8] Ganot's textbooks were certainly amongst the most widely translated and read, and as such made a major contribution at an international level to the configuration of physics as a discipline. By the 1880s, they were considered standard works of physics by a wide range of readers across the social and cultural spectrum in France, as well as in countries such as Britain.[9] As I have argued elsewhere, this made them central to French and British culture.[10]

However, Ganot's textbooks are seldom (if at all) cited in the history of nineteenth-century physics literature, and they have only been the object of a very limited number of publications.[11] Furthermore, when they are cited, it is often in dismissive terms, informed by an historiographical prejudice that still too often categorizes pedagogy as a clearly distinct practice inferior to research.[12] The reasons for Ganot's absence in history can be clarified if we analyse the current major trends in the historiography of nineteenth-century physics.[13] Some of these can in fact be found to some degree in all major syntheses published in the last three decades.[14]

One of these major trends is the peripherality assigned to educational structures. Educational qualifications are usually mentioned and sometimes inserted in the discussion of the work of physicists, but it is the selection of the latter, along with their research work, that drives historical narratives. Furthermore, only higher education institutions are taken into account, and considered to be the only places where research and creative work is performed. By contrast, the work of Rudolf Stichweh and Kathryn Olesko has shown that, in Germany, the training of secondary school teachers and students had a fundamental role in the constitution of physics as a discipline, through its defining role in the physics community, its professional practices and the university curriculum.[15] Olesko and Andrew Warwick have also manifested the importance of considering pedagogical practices in relation to discipline building.[16]

In addition, physics is conventionally portrayed as a well-defined institutional field, clearly distinct from other disciplines. Thus, for example, in spite of the sensitivity of Iwan Morus' research to the role of medicine in the practice of electricity,[17] he has failed to make any connection between the rise of physics as a teaching discipline and medical education. By studying the place of Ganot's physics in the French and British educational systems, I argue in this paper that the intersection of secondary schooling, university medical and science education, and textbook writing had a fundamental role in shaping physics as a discipline in France and Britain.

Another major trend concerns three interconnected aspects, namely periodization, nationality and conceptual unification. The canonical periodization used by historians of nineteenth-century physics is characterized by a strong focus on late nineteenth- and early twentieth-century developments, a particularly important period for the constitution of physics as the discipline we know today. This periodization is structured through alternation of national hegemony. Developments in physics are considered to be predominantly French until the 1830s, and

British and German during the second half of the century. Accordingly, early French physics is often seen as a mere contribution to subsequent developments produced in Germany and especially Britain, and scientific communication between these countries is only examined in the particular moments when leadership transfer is considered to happen.

National developments are considered to be structured by conceptual unification programmes leading towards the *fin de siècle* consolidation of the discipline. Thus, physics is considered to have been defined first by the French Laplacian programme, and subsequently, in succession, by the correlation, conversion and conservation of forces in Britain, the conservation of energy in Britain and Germany, and Maxwell's field theories. As expressed by Rudolf Stichweh, this element of discontinuity in the historicization of physics is an attractive solution, as it allows presenting "physics" as an "invention", thus making the contingency of its origin a central object of discussion.[18]

However, this three-dimensional framework of time, space and epistemological foundation has in fact favoured narrative linearity and contributed to narrow the historical and ontological diversity of the field.[19] In terms of time, this narrative is teleological in assuming, more or less explicitly, that nineteenth-century developments add up to form twentieth-century physics. In terms of space, it is geographically narrow, implicitly assuming a centre-periphery model in which physics is defined by one or two countries being central in a certain period, and diffusing knowledge to the rest.[20] What happens in peripheral countries, or in those slipping from their central position in periods of loss of hegemony, is not considered relevant. It is inaccurately assumed that the local practices and conceptual frameworks in force at the centre are predominant everywhere. In terms of epistemological foundation, it is assumed that the different conceptual unification processes in physics can be subject to early disagreement and debate, but that they end up in generalized consensus and acceptance everywhere.

In this perspective, books like those of Ganot would therefore not belong to an hegemonic period of French physics and can thus be ignored. By contrast, as argued by Faidra Papanelopoulou in this volume, the practices defining nineteenth-century physics were diverse within the same country and in the international context. Furthermore, she has shown the relevance of studying French physics in periods outside of the aforementioned canonical national periodization.[21] Ganot's books offer a big picture of nineteenth-century physics in which mid-century developments are core. The study of their French and English editions pinpoints the diversity of epistemological frameworks and practices coexisting in physics in different periods and places. Thus, for example, both gave distinct (but in both cases small) relevance to the principle of the conservation of energy in a period in which it is conventionally assumed that this conceptual framework pervaded physics. In fact, a careful analysis of nineteenth-century physics textbooks in different countries is still necessary in order to determine how common the unified picture of physics was, in the form of conceptual frameworks such as that of the conservation of energy. Due to their international relevance, Ganot's textbooks are a good starting point to undertake this task.

Surprisingly, historians of nineteenth-century physics have in general failed to assess the relevance of the fact that, during most of the second half of the century, French textbooks had a fundamental role in the education of British school and college physics students.[22] Communication regarding educational matters between these two countries had an important role in this process. A transnational analysis of French and English science education allows the dismissal of many stereotypes and exceptionalities that have been built on the basis of national histories. In this context, physics textbooks are privileged sources as the meeting point of the spaces defined by physics research and teaching, educational organization and curriculum design, instrument making and publishing.[23] Furthermore, this case study allows the implementation of James Secord's proposal of making communication central to history of science narratives by emphasizing the connections between pedagogical, research and popularizing practices, between textbook and journal science, and lecturing, and between oral, visual and printed communication, in international perspective.[24]

My aim in this paper is to show different ways in which making textbooks central can contribute to improve the historiography of nineteenth-century physics. Accordingly, I will first introduce a case study of the genesis and communication of Ganot's physics textbooks in France. Hence, I will consider the role played by Ganot and his pedagogical practice in the rise of physics in French education, in the context of conceptual and political tensions related to the configuration of this subject as a discipline. By studying the structure of the French educational system, I will highlight the role of medical faculties, secondary education and examinations in the shaping of physics and in the concomitant success of Ganot as an author. Furthermore, by examining the communication and appropriation of Ganot's physics from France to Britain, I argue that booksellers and students had an important role in this process, and, consequently, that they are actors to be considered in a study of the constitution of physics as a discipline. By analysing the role of Ganot's textbooks' English translator, I also provide a comparative perspective on physics and the organization of science education in England and France, and will study its contribution to the definition of distinctive features differentiating the English translations from the French originals.

Ganot's authorship and the rise of physics in French education

The inauguration of Ganot's role as an author came together with four events of extreme relevance for his book.[25] After the revolution of 1848, the Association Philotechnique had been founded as an institution offering free courses to the working class in Paris. Ganot was an original member and taught physics in the school. The Philotechnique was a split from the Association Polytechnique – founded in 1830 by students of the École Polytechnique – constituted by members of the latter that considered that its courses were too elitist for the workers of the Parisian workshops.[26] In 1850, after fifteen years experience as a teacher of mathematics and the sciences in the private school of the chemist Alexandre Baudrimont, Ganot opened his own school in Paris. His entrepreneurial action was favoured by the Falloux law that year, promoting private initiative through educative freedom. In spite of its major aim to favour the Catholic Church regaining control over education, this law also boosted the opening of secular private schools like Ganot's in Paris, preparing students for scientific careers.[27]

As in Baudrimont's institution, the aim of Ganot's school was to prepare candidates for university and engineering studies and for the *baccalauréat ès-sciences*. This examination was the scientific equivalent of the *baccalauréat ès-lettres*, both created in the early nineteenth century with the Napoleonic national reforms of education. During most of the century, the *baccalauréat ès-lettres*, sanctioning classical studies, had ruled education, as the requirement for the culmination of secondary education, and also for accessing any literary or scientific studies in higher education. The *baccalauréat ès-sciences* was merely optional.

However, this examination was about to acquire an unprecedented relevance. In the 1830s, it had acquired further importance by being requirement for enrolment in the medical faculties. In the late 1840s, this examination – administered by the French state network of faculties of science[28] – had also for the first time been made a requirement for candidates for the *Écoles du Gouvernement*.[29] Its definitive expansion came in 1852, when the reform called the *bifurcation* created two parallel specializations in secondary education, giving equal status to the two *baccalauréats*. As a consequence, student numbers for the *baccalauréat ès-sciences* were decisively boosted, equalling those of the classical *baccalauréat*.[30] The number of hours assigned to physics in the secondary school curriculum doubled, and consequently there was an important increase in the number of teachers, strengthening the identity of this professional collective.[31]

The rise of the *baccalauréat ès-sciences* and the faculties of science was the result of the confrontation between two different approaches to education and to physics, played in the battlefield of the Conseil de l'instruction publique ─ the highest state organ in educational matters. The position of mathematics and the École Polytechnique was represented by Siméon-Denis Poisson who believed in the mathematical character of physics, and thus coupled the teaching of these two subjects, against the position of physics as experimental science and the faculty of science, represented by Louis-Jacques Thénard who stressed its links with chemistry. Due to Thénard's actions, in 1840, for the first time the *agrégation* – an examination designed on a German model to provide teaching positions in secondary and higher education – was split in two specializations: mathematics and sciences.[32] Thénard's efforts were decisively continued by his assistant Jean-Baptiste Dumas, a student trained in Geneva and Paris, who succeeded him in all his positions, representing through his chemistry professorships the link between the French faculties of medicine and of sciences, and the experimental approach to physics. Dumas was the major actor in the design and promotion of the *bifurcation*.[33]

Several factors converged in its successful promotion. On the one hand, there was the rise of the faculty of sciences against the École Polytechnique, and the consequent disciplinary rise of physics and chemistry against mathematics. On the other, there was the related strategy of promotion of the sciences and scientific teaching careers by the members of this faculty and of the École Normale – a special institution in charge of training science teachers – as a way to strengthen their position in French society. French scientists argued for the need for more science teaching in order to improve the country's industrial development. England was cited as an example of the major role given to the "application" of the sciences to industry in education, and Germany, as a country which had already started to follow this direction.[34] Although incubated during the previous decade, the *bifurcation* was implemented only a year after the Great Exhibition, and similar arguments were critical to debates on middle-class education promoted then in England by British scientists. These, however, used France as the model to follow in the organization of science teaching and research, and also cited Germany in similar terms.[35] Finally, after the coup d'état of Louis-Napoléon, the same year, the *bifurcation* also aimed at regaining state control over education by counteracting the promotion of religious schools by the Falloux law, taking into account the latter's usual specialization in the classical curriculum.

Teachers and authors like Adolphe Ganot were eager to exploit the possibilities offered by this new framework. Since the 1830s, he had taught both mathematics and the sciences (especially chemistry and physics). In the 1840s, while maintaining his profile as a science teacher, he increasingly specialized in physics, a process culminating in his authorship of the *Traité*. In the same period Louis Pasteur – like Ganot a student of the École Normale – went against the advice of his father, who tried to orient him towards mathematics because of its perceived prestige. On the contrary, he decided to specialize in sciences and, in 1846, he got through the *agrégation* his first appointment as secondary school physics teacher, which was the start of a successful career in science.[36]

The aims and pedagogical structure of Ganot's *Physique*

In 1855, Ganot's school had 180 students and he expected an increase in numbers of approximately one-third every year.[37] Most of the students studied medicine and pharmacy, with less than five candidates per year going on to the military École de Saint-Cyr and to the École Polytechnique.[38] However, the publication of his textbook allowed him to expand and to diversify his audience beyond his school classroom. After its first edition (1851), the subtitle of his book targeted any student following courses in secondary schools, science faculties and engineering schools, as well as those not engaged in formal education, but interested in the "applications" of physics.[39] Ganot also showed that he expected his book might be read by foreign authors, translators and publishers, since he inserted a note concerning international prosecution for piracy.

With his book, Ganot aimed at reproducing in printed form, the oral, visual, and manuscript form defining the physics courses he gave in his school.[40] Thus, he stressed that the numerous illustrations in the *Traité* were reproductions in perspective of the instruments of his cabinet, by first-rate artists, whose work he had carefully supervised. The quality and up-to-date character of the *Traité*'s illustrations were stressed by reviewers such as the abbé Moigno, who complained of the common use of old eighteenth-century and early nineteenth-century illustrations in many contemporary textbooks.[41] Indication of instrument size accompanied

Ganot's illustrations, and the use of letters and numbers assisting their description in the text completed this printed replication of the classroom experience. Illustrations of recently designed instruments available in the shops of leading Parisian makers completed the *Traité*'s instrumental display. Ganot often mentioned the makers and his visits accompanied by a draughtsman to their workshops – most of which were close to his school – in order to prepare printed replicas of their products.

The final high quality product was obtained through collaboration with the printer Jules Claye, renown in France and abroad for his aesthetic taste, technical skill and mechanical inventions, which allowed him to print superb wood engravings cheaply. After Claye was awarded a Prize Medal at the London Great Exhibition, the major scientific book he displayed in 1855, at the subsequent Paris Exhibition, was Ganot's *Traité*.[42] Indeed, scientific collections were considered by Ganot a fundamental aspect in advertising his school. His cabinet of physics was presented as holding around three hundred pieces of apparatus, all "amongst the most modern",[43] roughly the same number as represented through illustration in his *Traité*. His collection seems to have been displayed in glass-fronted cupboards around the lecture hall of his school.[44] The large investment required for such collection might have been facilitated by his inheriting the collections of Alexandre Baudrimont's school after he departed Paris to take a professorship at the faculty of sciences of Bordeaux. The spread of his investment in the production of the first edition of his book was secured by publishing it in two parts – a common financial strategy in the French book trade.[45]

Although I have not found direct evidence of Ganot's school lessons, a certain amount of his pedagogical practices can be reconstructed indirectly. Ganot's school certainly had a direct connection with the school of Baudrimont, in which he previously worked. As already mentioned, he probably inherited the school's equipment and certainly preserved part of its staff. The calendar design of Ganot's courses was similar to that of Baudrimont's,[46] and, arguably, he used the pedagogical experience he had acquired in his school, and adapted it to a new educational framework, characterized by an increase in students, the possibility of entering in direct competition with the state secondary schools, and the increase of the status of physics.

A published description of Baudrimont's school courses helps us to imagine what would have been included in Ganot's teaching. According to Baudrimont, the short length of his courses in relation to the normal curriculum taught at the state schools allowed students to go into greater depth in the most relevant questions without loosing a general picture of the subject. Every lesson in his school consisted of an exposition for one hour, followed by an interrogation of fifteen minutes. The student was thus placed in similar conditions as in the examinations they were preparing for. In chemistry and physics, experimental demonstrations were performed by the teacher in front of the students. Collections of physical instruments, chemical products, medicine and zoology were kept in glass-fronted cupboards, in the lecture hall to allow the students to see them continually and to remember more easily the subjects explained using them.[47]

In fact, this picture coincides with that provided by Jean-Baptiste Dumas in his report leading to the *bifurcation* reform. Dumas praised the pedagogical methods used in many private preparatory schools and recommended their implementation in the state schools. He remarked that, in contrast with the latter, the competence of the preparatory schools' headmasters and teams of specialized teachers, the close supervision of students, and the reproduction of examination conditions through regular interrogation was superior. Moreover, he stressed the indispensability of implementing pedagogical practices and material resources, articulating the teaching of science through demonstration, experimental manipulation and observation, and illustrating it through its major current applications.[48] As I have suggested, these ideas informed the organization and pedagogical practice of Ganot's physics courses and their oral, visual and manuscript form, which were then replicated in printed form through the publication of the *Traité*.

Thus, for instance, from its second edition, the book included an appendix of questions and problems based on the *baccalauréat ès-sciences* examination questions. Ganot's was not the first book of physics problems published in nineteenth-century France, but he certainly was pioneer in condensing in a book all the pedagogical practices defining the teaching and learning of physics in this context, including interrogation and examination. This characteristic is related to its origin in the context of French private preparatory schools, and was subsequently generalized in most French physics textbooks, and concomitantly in French state schools.

With the publication of successive editions of his book Ganot aimed at expanding his readership beyond the walls of his classroom. Accordingly, through collaboration with his printer, he used a special system of asterisks and small size type to introduce selective discrimination of the contents of his book. This allowed him to target readers enrolled in different educational structures, covering the whole spectrum of science education in the critical area of access to higher education. Furthermore, the small size type system distinguished the basic contents of the book from those directed to more advanced readers. These often contained more advanced algebraic calculus, contrasting with the main text, which was characterized by its mathematical simplicity. Indeed, the *Traité*'s major emphasis was on instrument design, and experimental procedures. In addition, small size type was also used to mark accounts of physics developments that, because of their novelty and Ganot's perception of the relative consensus surrounding them, were not considered ready to be part of the main course. In subsequent editions, some of these contents could be integrated in the main body of the text, or conversely be eliminated, when the author judged they had been superseded or ruled out.

These were the only instances in which Ganot explicitly cited his sources. Accordingly, we know that he read periodicals such as the abbé Moigno's *Cosmos*, Germer Baillière's *Revue des cours scientifiques*, and the more elitist *Annales de chimie et de physique* and *Journal de physique*, and books such as John Tyndall's *La Chaleur*, Rudolf Clausius' *Théorie mécanique de la chaleur*, Angelo Secchi's *L'unité des forces physiques*, William Grove's *Corrélation des forces physiques* and Auguste de la Rive's *Traité d'électricité*. He thus kept abreast of developments in physics through the accounts and lectures by French and foreign authors published in French scientific periodicals, and through more advanced treatises published in French, and through translations of foreign books into French. A relevant number of these translations were performed by authors inhabiting the same pedagogical, scientific and social space as Ganot in Paris, and whom he befriended, such as the abbé Moigno and the Dr. Deslechamps,[49] so he may also have known about foreign research through conversation with them. Analogously, he informed himself about new developments in instrument design by visiting international leading instrument makers' workshops in Paris, most of which were located in the vicinity of his school.[50] In addition, he had access to the numerous World Exhibitions celebrated in Paris during the second half of the century, and thus obtained illustrations and descriptions for instrument patents recently presented.

If Ganot used periodicals and books produced in Paris to update successive editions of his *Traité*, the process of communication and appropriation also worked in the other direction. Thus, for instance, in 1867 the abbé Moigno's account in his journal *Les Mondes* of the World Exhibition, held in Paris that year, reproduced a large number of descriptions and illustrations of the instruments presented there from the thirteen edition of the *Traité*. With Ganot's permission, they appeared a few months before the publication of his book.[51]

Through his editorship of the journals *Cosmos* and *Les Mondes* between 1852 and 1881, François-Napoléon Moigno had an important role in the communication of foreign science in France and vice versa. His journals offered regular accounts on foreign research, and had an international readership and correspondence. They also are a monumental testimony of his frantic activity as journal editor and man of science.[52] For instance, he regularly attended the meetings of the British Association for the Advancement of Science, and accompanied Parisian instruments makers like Jules Duboscq to participate in public demonstrations in London at the Royal Polytechnic Institution.[53] Furthermore, he contributed to international scientific communication through his translation into French of works from the English of John Tyndall, William R. Grove, August Wilhelm von Hofmann and Ebenezer C. Brewer and the Italian of Angelo Secchi, some of which were read by Ganot.

In turn, Moigno published in his journals praiseworthy reviews of Ganot's books.[54] Moreover, through his collaboration with Molteni, a firm making projection lanterns, he designed a large collection of projection slides for teaching purposes. This collection included a physics course with 138 slides all based on the illustrations of Ganot's *Cours*.[55] From the inception of *Cosmos* onwards, Moigno considered his journal as only one side of his educational mission. He expressed his intention of completing the journal's written teaching with "an even more efficient teaching, that which comes through the senses of hearing and sight". Accordingly he intended to establish a hall in Paris for the teaching of science through lectures with the aid of projection lanterns using electric light.[56] Moigno had in fact been impressed by this technique, that he had witnessed in London at the Royal Polytechnic Institution, and through his collaboration with Molteni and Duboscq he pioneered its use in popular education in France.[57]

In fact, one of Ganot's major aims in writing the *Cours* had been to provide an elementary physics book for those readers who had no access to real instrument collections, which were very expensive. This purpose was achieved by including a large number of illustrations which, by contrast with those of the *Traité*, included human figures manipulating instruments. Illustrations were thus supposed to act as substitutes for real instruments and experimental demonstrations whenever those were not available.[58]

By rewriting the *Traité* in a different form through the publication of his second textbook, the *Cours*, Ganot further expanded his readership, targeting readers enrolled in the higher ranks of female primary education, in the secondary school literary classes, and in the context of informal education and social conversation.[59] Furthermore, as shown in the introduction of this paper, Ganot's textbooks were read beyond France. The next sections are devoted to discuss how Ganot's *Traité* was communicated and appropriated through its English translation.

International booksellers and the communication and appropriation of Ganot's *Physique* in England

By the mid nineteenth-century, Paris, Leipzig and London formed a major triangle in the international book trade. In addition to the large concentration of French booksellers in Paris, supplying the faculties, engineering schools and other teaching and research institutions, the city hosted a large number of foreign booksellers. The latter had typically first been trained in their native countries and subsequently came to Paris to complete their education before establishing businesses. Some of them stayed, and their experiences allowed them to serve as focal points of the two cultural spaces formed by their native and adoptive countries.[60]

The medical and science faculties in Paris also attracted a considerable number of foreign students. Around one fifth of the foreign students registered at the medical faculty in this period were British.[61] On completion of their degrees, they returned to their home countries, and acted as mediators between French science and medicine and their own national research and teaching contexts, often engaging in making foreign works available through translation and through reviews and regular accounts in journals. This was often made possible through collaboration between students and foreign and native booksellers.

French booksellers had a leading role in the international book trade during the nineteenth century. Early in the century, different Parisian firms opened branches in other countries in order to expand their market, as well as to protect their national businesses from bankruptcy due to overproduction, and from piracy – the most common reasons for crisis at the time. During the century, England was the main market – after Belgium – for French books, and French international booksellers typically structured their businesses by establishing branches in at least the three major leading metropolises of the book trade, including London.[62] In this context, the Baillières were arguably the most important international medical and scientific publishers and booksellers operating in mid-nineteenth-century Britain. The bookshop and publishing business established by Jean-Baptiste Baillière in 1818 in Paris acquired leading status in France over the following decade through acting as bookseller to the Academy of Medicine. In the following decades the house expanded abroad through the work of his brothers and nephews. By the 1860s, the family had successfully established bookshops and publishing businesses in London, Madrid, New York and Melbourne.[63]

In this period, J.-B. Baillière published a bibliographical catalogue of French and foreign medical and scientific works, fulfilling the role of promoting bibliographical practices and advising men of science on recent publications, and also advertising the books available at his shop. As a well-known book in the Parisian medical and scientific context, successive editions of Ganot's *Traité* were included in the Baillière catalogue as soon as they appeared or even some months before.[64] At the same time, the book was advertised from the early 1850s in the catalogues of Jean-Baptiste's brother, Hippolyte, director of the London and New York branches.[65] Thus, from an early stage, the Baillières made Ganot's *Traité* available in Britain and America.

Although Jean-Baptiste and his brother Germer (who had opened another bookshop in Paris in 1830) specialized in medicine, they also published books on chemistry, physics and natural history, in alignment with the role that the sciences played for medical students in relation to the *baccalauréat ès-sciences*, and the teaching of these subjects as "preliminary" sciences in the curriculum of the French medical faculties. However, they could not compete in this field with other strictly scientific booksellers in Paris.

By contrast, when Baillière started to publish, in London, English translations from French and German authors, as well as works by British authors, Hippolyte soon detected the lack of elementary treatises in physics, thanks to his Parisian experience,[66] and identified the potentially emergent market of scientific secondary education.[67] In 1847, he published Johann Müller's *Principles of physics and meteorology*, a translation of a German work that was itself a short version of a translation of a textbook by Claude-Servais-Mathias Pouillet from French into German.[68] The second physics textbook published by Baillière, between 1861 and 1863, was *Elementary Treatise on Physics Experimental and Applied*, a translation of Ganot's *Traité*.[69] As already explained, this work, had its origins at the crossroad of French medical and secondary school education, a context well known to Hippolyte and his brothers.

Both Ganot's and Müller's books were part of a *Library of Illustrated Standard Scientific Works* launched by H. Baillière, which also included works by British authors such as the chemist Thomas Graham and the histologist and microscopist John Quekett. J.-B. Baillière was renowned in Paris for the quality of the illustrations in his publications, and his brother Hippolyte aimed to reproduce this standard in England by designing the aforementioned collection in addition to other projects such as anatomy, surgery, botany and geology atlases.[70] Ganot's care for the illustrations of the *Traité*'s together with Claye's first-rate professional contribution made it an excellent work to be integrated in Baillière's *Library*.

In keeping with Baillière's standard commercial practices, the *Treatise* was issued in England in monthly parts. As already mentioned, this practice allowed publishers to spread their investments over a longer period, as well as to attract subscribers. It was also used to fight piracy, as subscription sales allowed market share to be fully taken up before the whole work was completed. In addition, it facilitated distribution, as book parts could be sent by post like newspapers. This practice was characteristic of the publication of cheap literature and of novels appearing in the periodical press, but also of large encyclopaedic works or dictionaries and of expensive volumes with large numbers of illustrations, in publishing which J.-B. Baillière had a long experience.[71] Hence, Baillière's commercial strategies made the publishing format of the periodical press and of large encyclopaedic works cohere with that of textbooks.

Ganot's identification in the title page of the *Traité* as "professeur" – a term used in France for any teacher in secondary and higher education (in line with the idea of "université") – was transformed by Baillière in "professor" – used in Britain only to strictly designate university positions – thus, enhancing the author's authority. Furthermore, the *Traité*'s system of asterisks and small size type was completely eliminated in the *Treatise*. This printed feature of the highly stratified French educational system was difficult to adapt to the emerging English system, and in addition, apparently, English readers did not like it.[72] As we will see, this modification had important consequences in the configuration of the book as a new product through the work of its translator.

Edmund Atkinson and the teaching of physics in mid nineteenth-century England

Through the recommendation of one of his peers, the London publisher William Francis, Baillière assigned the translation of the *Traité* to Edmund Atkinson,[73] a young chemist and active Fellow of the Chemical Society, whose journal and proceedings Hippolyte published. Francis, who had previously been in charge of this task, knew Atkinson through his regular contribution to his *Philosophical Magazine*, with translations and accounts of recent Continental researches in chemistry, especially German and French.[74] Previously, after being educated at Owens College, Manchester, under Edward Frankland, Atkinson had, like Francis, studied in Germany, where he took a PhD in chemistry. After a subsequent research stay in Adolphe Wurtz's chemistry laboratory at the faculty of medicine in Paris, he had returned to England and engaged in teaching and journal writing.[75] In the scientific and medical context of Paris, Atkinson was likely to have noticed the success of Ganot's *Traité*, and in the preface to its first English edition, he stated that his high regard of the book was informed by the previous use he had made of it in teaching.[76]

Atkinson's teaching career started in the 1850s – after returning from his training in Germany and Paris – at Queenwood College, a pioneering science school in which Frankland and John Tyndall had met and taught a decade earlier, before themselves going on to do postgraduate research in Germany. When he started to work on the translation of Ganot's *Traité,* he was Lecturer in Chemistry and Physics at Cheltenham College. In 1863, when the translation was completed, he transferred with the same title to the Royal Military College, Sandhurst.

In the 1860s British education was assessed by Jean Demogeot and Henri Montucci, two French commissioners chosen for this task by the French minister of public instruction. Their survey was part of a larger preparatory enterprise organised on the eve of reforms in education in France, in which commissioners were also sent to Prussia, Austria, Sweden, Switzerland and the USA.[77] After being submitted to the minister, Demogeot's and Montucci's report was printed in a high-quality edition by the French national press. Although it received some criticisms in Britain, it was in general praised for its meticulosity and accuracy together with its gentlemanly respect. And British writers considered it to be a Continental standard reference work on British education.[78]

For Demogeot and Montucci, science education was underdeveloped in England, in comparison with France. In certain occasions, in journals and newspapers, English reviewers explicitly pinpointed this comparative state of affairs as the reason for the success of French and German textbooks in England.[79] Only schools such as Cheltenham, Marlborough and a few other institutions in industrial towns such as Liverpool were considered by Demogeot and Montucci to match the level attained by French education through the *bifurcation*. In this sense, they considered that the development of national systems of examinations such as those of the civil and military service, the London university matriculation, the Oxford and Cambridge Locals and the Society of Arts, and those for teachers held by the College of Preceptors, had had a fundamental role in starting to raise the quality of secondary education and in the introduction of the sciences in this level of education. However, English education was still considered to be particularly oriented towards the classical curriculum, and the national standard of education to be irregular and heterogeneous.[80] In addition to the examinations they mentioned, it is worth to pinpoint the powerful action exerted by the Science and Art Department, a state department funded through the benefits of the Great Exhibition. Through its system of teacher training and school examinations, and the pedagogical and political action of teachers such as Edward Frankland, Frederick Guthrie and Thomas H. Huxley, the Department exerted a comparable – although not equally omniscient – function to the École Normale in France.[81]

Cheltenham College, together with the colleges at Marlborough and Wellington, was one of a new type of large proprietary school founded in the 1840s and 1850s, and that soon acquired the first grade status of public schools. They were, however, distinct from traditional public schools in that they developed differentiated curricula which included the teaching of the sciences for the preparation of candidates for the army and civil service. Thus, they had a close relationship with the Royal Military Colleges at Sandhurst and Woolwich. By contrast, the old public schools – with the exception of Rugby – kept their curricula in the classical ideal for decades.

Through his pedagogical practice at Chelthenham and Sandhurst, and his translation of the *Traité*, and subsequently of the *Cours*, Edmund Atkinson had a prominent role in the development of physics as a school subject, and concomitantly as a discipline in England. When he died in 1901, his colleagues George Carey Foster and Hugo Müller remembered him as one of the first teachers who had taught physics systematically in a large public school.[82] Trained as a chemist, he successfully moved to physics, decisively contributing to it through his teaching and textbook writing. He was not the only mid-nineteenth-century physicist with this profile. In France, Ganot had taught chemistry before publishing his *Traité*, although he did not produce research in this field, and he also taught mathematics in the particular context of the French school curriculum. But another English chemist trained in Germany, Frederick Guthrie, had also a fundamental role in the configuration of physics, through his position at the Department. Analogously, George Carey Foster, professor of physics at University College, London, was originally a research chemist who had finished his training in German, Belgian and French laboratories. Atkinson's translations of Ganot's books were used by generations of teachers and students, and were recommended in a wide range of English examinations (including those of the Science and Art

Department and London University), contributing to the shaping of physics as a discipline in Britain and abroad.[83]

Edmund Atkinson's appropriation of Ganot's *Physique*

Atkinson's translation of the *Traité* transformed the book in several ways. First, together with the publisher, he helped shape their intended audience. The book was addressed to "Colleges and Schools", and it was certainly used in many British colleges, schools and medical faculties during this period and was standard for the preparation of a wide range of science examinations.[84] Furthermore, he reshaped the contents and form of the text in significant ways, according to his pedagogical practice as a teacher, and in alignment with the evolving context of scientific education in England. This process was constrained by the internal mechanics of the book that, as I explain later, can be considered as vademecums, in the sense coined by Ludwik Fleck.[85] Finally, he appropriated Ganot's section of problems as an author.

In the preface to the *Treatise*, Atkinson valued the book for its large number of editions and translations, its "clearness and conciseness" and "methodical arrangement", and the quality of its illustrations. However, because of its close link to the "French systems of instruction", he thought necessary to make "alterations and additions" to meet the needs of the English student. In its first edition, his translation was often literal and, in general, did not significantly supplement the *Traité*'s contents. However, it was characterized by more synthetic sentences, shorter historical introductions, different examples, more algebraic formulae (still, simple ones), a more quantitative and mathematical approach, the recalculation for London of observational data given for Paris, and a stronger anti-realist approach in relation to the physical agents and the theories of electricity. Both Ganot and Atkinson explicitly discriminated new conceptual or theoretical frameworks by sometimes choosing new theories for pedagogical reasons, such as prioritizing simplicity and tradition for the sake of readers. However, as we will see, Atkinson was more sensitive, for instance, to the doctrine of the conservation of energy, showing the emerging importance that this framework had in Britain.

In subsequent editions, Atkinson introduced new contents and significantly changed some sections. The first parts to be completely reshaped were the introductory chapters on mechanics, which Ganot had limited to a minimum, due to the greater independence in relation to physics of this subject in France, by contrast with Britain.[86] In addition, Atkinson introduced new contents related to recent research conducted in

Britain, as well as results originally published in English and German. Sometimes additional illustrations were added, often referring to local instrument makers.

New articles were typically introduced at the end of chapters, keeping intact the general structure of the book. The *Traité* included results produced in France, but also in England, Germany, Italy and other countries. However, as already mentioned, Ganot's knowledge of foreign research was based on its appropriation by French journal writers, and translators. Following Fleck's distinction of "journal" and "vademecum" science, Ganot's book was not a mere aggregation of journal articles but, a closed organized system, a vademecum. The tight internal mechanics of the structure of the *Traité*, and perhaps the possibility of saving labour on the basis of Ganot's regular new editions,[87] are factors which configured Atkinson's appropriation. Hence, he respected the general structure and most of the contents of the *Traité*'s successive editions, and in general, introduced additions only at the end of chapters. Thus, for instance, Atkinson never completely reconfigured the *Treatise* in terms of the driving concept of energy conservation, promoted in Britain from the 1860s; however, he introduced an article on this subject at the end of the first book of the *Treatise* as early as 1868.

In spite of the general praise received by Ganot's English translations, they were sometimes criticized and the role of the conservation of energy in the structure of the book was a topical question. In 1872, George Rodwell – physics professor at Marlborough College – regretted the limited space devoted to this doctrine, considering it had a fundamental role in defining current and future physics.[88] A year later, Atkinson expanded his treatment of this topic by including a lengthy discussion of work, energy and the principle of the conservation of energy. By 1880, Ganot's account was instead based on the earliest formulation of the correlation and conversion of forces. However, Atkinson still respected the main structure of Ganot's book and usually added new matter at the end of chapters.

The close links between translation and authorship are especially noticeable for the case of Atkinson's appropriation of the *Traité*'s problems. Atkinson included this section from the *Treatise*'s seventh edition (1875), arguing that teachers and other users of the book had conveyed to him the need. He found many of Ganot's problems devoid of interest in having only algebraic or geometrical solutions, so he added new problems focusing on the use of physical principles, based on his teaching experience and that of his colleagues.[89] In addition, the appendix was published separately in 1876, with Atkinson identified as the author.

After Hippolyte Baillière's death in 1867, Atkinson proposed translating Ganot's *Cours* to Longmans, the most important London publisher in this period.[90] Its first edition, published in 1872, as *Natural Philosophy for General Readers and Young Persons*, was addressed to students at a more elementary level of instruction.[91] It was therefore a priority to eliminate the *Treatise*'s mathematical formulae. Considering it would be difficult to produce a coherent work by expurgating the *Treatise*,[92] Atkinson preferred translating Ganot's *Cours*, which he knew had already had an extensive circulation in France. His translation introduced modifications aimed at targeting students in the English upper classes of boys' and girls' schools, and candidates for the University of London matriculation examination. It was also considered suitable for the general reader wishing to acquire knowledge of the main physical phenomena and laws in "familiar language".[93]

The London examinations included a fair amount of science and, from the 1860s medical and science students sat for the same papers in the first stage of their university education. As a traditional faculty, medicine attracted a large number of students, strengthening the presence of the sciences in the university curriculum. Furthermore, these examinations also had an important role in articulating the teaching of science in England as they became a certificate sought by students aiming either to follow a career in science or simply to crown their school education with a certificate, and thus they directed the curriculum and performance of a certain number schools.[94]

The *Traité* and the *Treatise* shared the aim to be reference textbooks for students enrolled in the last courses of secondary school and in the first courses of higher education, and for students preparing for major science examinations giving access to higher education in France and England, respectively. The *Cours* was characterized by its target in the higher ranks of primary education teacher training and the candidates to the classical *baccalauréat*. By contrast, *Natural Philosophy* was built as a treatise aimed at the preparation of university access examinations, so it developed as a book targeting students in the higher levels of formal education. In spite of this, both the *Cours* and *Natural Philosophy* shared their target of self-taught readers and those bringing science into social conversation, an intention certainly favoured by their use of the same illustrations.

Conclusion

The international presence of Ganot's textbooks during the second half of the century challenges the canonical periodization and national mapping of physics in this period. A preliminary comparative analysis of these textbooks and their English translations suggests that by the 1880s, although the doctrine of the conservation of energy had an increasing role in the perception that physicists had of their emerging discipline, it did not have the general consensus that is usually attributed to it. Furthermore, the increasingly important status it had in Britain was not equally shared in other countries such as France.

Concomitantly, there were other fundamental aspects that contributed to shape physics as a discipline. The important role that the sciences had in the preliminary education of medical students and the support that the well-established medical faculties provided for the teaching of these subjects was decisive in France and in England for the expansion of the public and professional community of physics. The experimental connection of physics and chemistry and its convergence in the medical curriculum contributed to the emergence of a community of physicists whose focus was more experimental than mathematical. On the other hand, the development of secondary education, through the establishment of schools, national systems of examinations and teacher training programmes was also essential for the rise of physics and contributed to shape this discipline, both in its contents and its form. As a meeting point of these various factors, Ganot's textbooks illuminate the different actors and phenomena that contributed to configure physics.

International communication played a fundamental role in this context, and students, booksellers and journal editors were important actors in this phenomenon. France and England observed each other through politics, educational organisation, scientific practice and technological innovation. The observation of the other went beyond rhetoric and was used in the efforts to promote pedagogical reforms, scientific practice and emerging disciplines such as physics. Internationalism was present, to different extents, in the work of textbook authors and teachers such as Ganot, Atkinson, Guthrie and Carey Foster, journal editors such as Moigno and Francis, and publishers such as Jean-Baptiste and Hippolyte Baillière. Their appropriation of practices and knowledge through their experience of foreign cultures contributed to the shaping of pedagogy, educational organization, and physics in particular, and science and medicine in general, in their respective countries.

As emphasized in this paper, literary genres had fluid boundaries in this period and physics was communicated and appropriated in a wide range of forms including oral and visual communication, teaching, public display and textbook and journal reading. Textbooks are an important source to attempt to recover this diversity defining science in this period.

Comparing the French and English Ganot also allows us to highlight the common importance of national examinations in shaping pedagogical practices and physics as a discipline. The French model of state educational control has conventionally been opposed to the English *laissez faire* tradition and national heterogeneity. However, the role of Ganot's textbooks and his school highlight the importance that the interaction of private and state initiative had in the configuration of the sciences and its teaching in France. The role of Atkinson and his textbooks suggests the importance of the new public schools and the military academies in the promotion of the science curriculum in England. Moreover the different examination systems instituted in England in this period had a national coverage – although it was heterogeneous and dependent on local initiative – and institutions such as the Science and Art Department were funded by the state, suggesting potential comparisons with the French École Normale.

Notes

[1] Ganot, A. (1851). *Traité élémentaire de physique expérimentale et appliquée*. Paris: Chez L'Auteur, Éditeur.
[2] Moigno, F.-N. (1868). *Cosmos* 16 (janvier-avril): 306.
[3] Archives Nationales (Paris), F17 20793, *Ganot* file.
[4] Ganot, A. (1859). *Cours de physique purement expérimentale*. Paris: Chez L'Auteur-Éditeur.
[5] Archive of the House of Longmans, *Atkinson File* (reel nº64, N107).
[6] Data consigned on the back page of Ganot (1880). *Traité*.
[7] Dates between brackets indicate the year of first editions. In most cases there was more than one. The Spanish and English editions were almost as numerous as the French.
[8] Paul, H. W. (1980). "The Role and Reception of the Monograph in Nineteenth-Century French Science". In Meadows, A. J., ed. *Development of science publishing in Europe*. Amsterdam: Elsevier, pp. 123-48.
[9] In fact, Ganot's books received more criticism from the 1880s onwards than in previous decades. However, this was due to changes in pedagogical thought that considered examinations and teaching through textbooks as traditional and deficient methods which did not lead to real learning. At the core of the pedagogical kingdom of physics, Ganot's textbooks were likely to be attacked as the symbols of the prevalent educational regime. See Anon. (1880). "Recent Electrical Researches". *The Times* Aug. 6: 3; I thank Graeme Gooday for pointing out this review to me.
[10] Simon, J. (2008). "Circumventing the 'elusive quarries' of Popular Science: the Communication and Appropriation of Ganot's Physics in Nineteenth-century

Britain". In Papanelopoulou, F.; Nieto-Galan, A., and Perdiguero, E., eds. *Popularising Science and Technology in the European Periphery, 1800-2000*. Aldershot: Ahsgate.

[11] Takata, S. (1987). "Ganot's Textbooks of Physics introduced into Japan". *Historia Scientiarum* 33: 25-41; Khantine-Langlois, F. (2006). "Un siècle de physique à travers un manuel à succès: le traité de physique de Ganot". *SFC*; Newton, D. P. (1983). "A French Influence on nineteenth and twentieth-century physics teaching in English secondary schools". *History of Education* 3 (12): 191-201. I would like to thank Seiji Takata and Françoise Khantine-Langlois for sending me their papers.

[12] Tannery, P. (1880). " [Review of *La Philosophie Scientifique* by H. Girard]". *Revue Philosophique* 9 (janvier-juin): 338-50; Fox, R. (2005). "The Context and Practices of Oxford Physics, 1839-77". In Fox, R. and Gooday, G., eds. *Physics in Oxford, 1839-1939. Laboratories, Learning and College Life*. Oxford: Oxford University Press, pp. 24-79, on p. 72.

[13] Some of the major synthesis produced in the last decades in this field are Harman, P. M. (1982). *Energy, Force and Matter: The Conceptual Development of Nineteenth-Century Physics*. Cambridge: Cambridge University Press; Purrington, R. D. (1997). *Physics in the Nineteenth Century*. New Brunswick: Rutgers University Press; Buchwald, J. Z. and Hong, S. (2003). "Physics". In Cahan, D., ed. *From Natural Philosophy to the Sciences: Writing the History of Nineteenth-Century Science*. Chicago: University of Chicago Press, pp. 163-95; Nye, M. J., ed. (2003). *The Cambridge History of Science. The Modern Physical and Mathematical Sciences*. Cambridge: Cambridge University Press; Morus, I. R. (2005). *When Physics Became King*. Chicago: The University of Chicago Press.

[14] Many driving concepts can be found in a seminal paper by Thomas S. Kuhn, although they have subsequently been developed in various directions. In the last account which appeared (*When Physics Became King*) Iwan Rhys Morus has contributed to enlarge the scope of most histories of nineteenth-century physics by recasting traditional accounts in the richer framework provided by cultural history. He acknowledges the international dimension of physics, but particularly focuses on Britain, and builds his account around national blocks corresponding to the latter, namely France and Germany. The book is original in its stress of the role of public display and instrument design. However, it also shares core historiographical tenets with its predecessors. T. S. Kuhn. (1975). "Tradition mathématique et tradition expérimentale dans le développement de la physique". *Annales. Economies, sociétés, civilisations* 30: 975-98, republished as (1976). "Mathematical vs. Experimental Traditions in the Development of Physical Science". *Journal of Interdisciplinary Science* 7: 1-31.

[15] Stichweh, R. (1992). *Zur Entstehung des modernen Systems wissenschaftlicher Disziplinen: Physik in Deutschland*. Frankfurt: Suhrkamp; Olesko, K. (1991). *Physics as a Calling. Discipline and Practice in the Königsberg Seminar for Physics*. Ithaca: Cornell University Press.

[16] Warwick, A. (2003). *Masters of Theory: Cambridge and the Rise of Mathematical Physics*. Chicago: Chicago University Press.
[17] See for example Morus, I. R. (1998). *Frankenstein's Children: Electricity, Exhibition, and Experiment in Early-Nineteenth-Century London*. Princeton: Princeton University Press, and (2006). "Bodily Disciplines and Disciplined Bodies: Instruments, Skills and Victorian Electrotherapeutics". *Social History of Medicine* 19 (2): 241-59.
[18] Stichweh. *Zur Entstehung des modernen Systems wissenschaftlicher Disziplinen*, p. 98.
[19] Despite Morus' insistence on the historical contingency of the facts presented, the periodization and national base of his approach makes difficult to avoid a linear reading of his account. See Morus. *When Physics Became King*.
[20] On centre/periphery see part V in this volume.
[21] Papanelopoulou, F. (2004). *The Emergence of Thermodynamics in Mid-Nineteenth-Century France*. Oxford: University of Oxford. unpublished D.Phil. thesis, and (2006). "Gustave-Adolphe Hirn (1815-90): Engineering Thermodynamics in Mid-Nineteenth-Century France". *British Journal for the History of Science* 39: 231-54.
[22] The major physics textbooks used by British students were those by Adolphe Ganot, Augustin Privat-Deschanel and Jules-Célestin Jamin. The first two were translated into English. These books remained canonical for the British student until the end of the century, but from the 1870s they started to compete with some books by British authors such as those by Balfour Stewart.
[23] Choppin, A. (1992). *Les manuels scolaires: histoire et actualité*. Paris: Hachette; Bertomeu Sánchez, J. R. ; García Belmar, A. ; Lundgren, A., and Patiniotis, M. (2006). "Textbooks in the Scientific Periphery: Introduction". *Science and Education* 15 (7-8): 657-880; Olesko, K. M. (2006). "Science Pedagogy as a Category of Historical Analysis: Past, Present, and Future". Ibid.: 863-80.
[24] See general introduction and introduction to this part in this volume.
[25] Before publishing his *Traité*, Ganot had contributed to a collective handbook aimed at students preparing for the *baccalauréat ès-sciences*, in which he wrote the sections on mathematics and part of the sections on chemistry. D'Orbigny, Ganot; Leblond; Rivière (1838*). Manuel a l'usage des aspirans au grade de bachelier es sciences physiques*. Paris: Bechet jeune.
[26] Pressard, A. (1899). *Histoire de l'Association Philotechnique*. Paris: Association Philotechnique.
[27] Belhoste, B. (2001). "La préparation aux Grandes Écoles scientifiques au XIXème siècle". *Histoire de l'éducation* 90 (mai): 101-30.
[28] By the 1850s there were sixteen faculties of science in France, one for each *académie* into which France was academically divided (Paris, Aix, Besançon, Bordeaux, Caen, Clermont, Dijon, Douai, Grenoble, Lyon, Montpellier, Nancy, Poitiers, Rennes, Toulouse and Strasbourg). A secondary school was created in the capital city of each of the 83 French *départements*, as well as in other important

towns able to provide the necessary funds and infrastructure for its organization. Fox, R. and Weisz, G. (1980). "Introduction: The Institutional Basis of French Science in the Nineteenth-Century". In Fox and Weisz, eds. *The Organization of Science and Technology in France, 1808-1914*. Cambridge: Cambridge University Press, pp. 1-28, on p. 5.

[29] Covering the whole spectrum of French engineering schools, including the École Polytechnique.

[30] In 1842, the number of candidates attending the *baccalauréat ès-sciences* was one sixth of that of the *baccalauréat ès-lettres*. In the 1850s and early 1860s, both examinations had approximately the same number of candidates, of around 4000 candidates each. Gerbod, P. (1965). *La Condition universitaire en France au XIXe siècle, Etude d'un groupe socio-professionnel. Professeurs et administrateurs de l'enseignement secondaire public de 1842 à 1880*. Paris: PUF, pp. 357, 384.

[31] Fournier-Balpe, C. (1994). *Histoire de l'enseignement de la physique dans l'enseignement secondaire en France au XIXe siècle*. Paris: Université Paris XI. unpublished PhD. thesis, p. 88.

[32] Anon. (1847). *Projet de Loi sur l'enseignement et l'exercice de la médecine et de la pharmacie….* Paris: Union Médicale-Victor Masson, p. 62.

[33] See Anderson, R. D. (1975). *Education in France, 1848-1870*. Oxford: Clarendon Press.

[34] Dumas, J. B. (1847). "Rapport sur l'état actuel de l'enseignement scientifique dans les collèges, les écoles intermédiaires et les écoles primaires, … (extraits) ". In Belhoste, B.; Balpe, C.; Laporte, T., eds. (1995). *Les sciences dans l'enseignement secondaire français. Textes officiels*. Paris: INRP-Éditions Economica, pp. 207-23.

[35] Gooday, G. (2000). "Lies, Damned Lies and Declinism: Lyon Playfair, the Paris 1867 Exhibition and the Contested Rethorics of Scientific Education and Industrial Performance". In Inkster, I.; Griffin, C.; Hill, J., and Rowbotham, J., eds. *The Golden Age. Essays in British Social and Economical History, 1850-1870*. Aldershot: Ashgate, pp. 105-20.

[36] Balpe, C. (1997). "L'enseignement des sciences physiques: naissance d'un corps professoral (fin XVIIie-fin XIXe siècle) ". *Histoire de l'éducation* 73 (janvier): 49-85, on pp. 62, 70; Chervel, A. (2004). "Lauréats des concours d'agrégation de 1821 à 1900". Paris: INRP. [http://www.inrp.fr/she/chervel_laureats1.htm] (accessed 10 September 2007).

[37] An increase that he probably managed to approximately maintain only during the 1850s, due to the partial dismissal of the *bifurcation* framework in the early 1860s, and the fierce competition between private schools.

[38] Ganot, A. (1856). *A messieurs les membres du jury de l'expropiation pour cause d'utilité publique ... Audience du onze février 1856*. Paris: Henri Plon, pp. 4-9.

[39] Such as barometry, steam machines, medical optics and electricity, and electrical "applications" such as telegraphy and lighting.

[40] As suggested by its wide intended readership and by Ganot's statements in an advertisement of his work inserted in its first edition. Ganot (1851). *Traité*.
[41] Moigno, F.-N. (1853). "Traité élémentaire de physique expérimentale et appliquée et de météorologie, par M. A. Ganot". *Cosmos* 3 (II): 513-4.
[42] Robin, C. (1855). *Histoire illustrée de l'exposition universelle*. Paris: Furne.
[43] Bottin (1851). *Annuaire et almanach du commerce, de l'industrie, de la magistrature et de l'administration*. Paris: Firmin Didot Frères.
[44] Ganot. *A messieurs*, pp. 3, 6.
[45] Ganot was probably prudent and produced an initial small print run of the *Traité*, since this, coupled with the rapid success of the book had him preparing a second print run a year later (I have found copies of the *Traité*'s first edition printed in 1852 instead of 1851, although they seem to be rare).
[46] Baudrimont offered a course of ten months, which could be taken in two parts of five months each, and quarterly courses starting every month. Ganot also offered quarterly courses.
[47] Baudrimont, A. (1836). *École spéciale de chimie théorique et pratique*, Paris : Paul Renouard, and (1837). *Enseignement préparatoire aux études médicales,…, sous la direction de M. A. Baudrimont*, …., n.p.
[48] Dumas. "Rapport sur l'état actuel de l'enseignement scientifique".
[49] Ganot (1866). *Traité* , p. 3; Ganot (1870). *Traité*, pp. 3-4.
[50] See series of papers on French instrument makers by Paolo Brenni in *Bulletin of the Scientific Instrument Society* (1993-6).
[51] Moigno (1867). *Les Mondes* 15 (août-décembre): 364-75.
[52] Redondi, P. (1988). "Physique et apologetique. Le *Cosmos* de l'abbé Moigno et de Marc Seguin". *History and Technology* 6: 203-25; Crosland, M. (2001). "Popular science and the arts: challenges to cultural authority in France under the Second Empire". *British Journal for the History of Science* 34 (3): 301-322.
[53] Moigno, F.-N. (1854). "Faits Divers. Nouvelles d'Angleterre". *Cosmos* 5 (28 juillet): 85-7.
[54] Moigno. "Traité élémentaire" (see n. 41).
[55] Moigno, F.-N. (1873). *Les Mondes* 30 (janvier-avril): 3-6, 667-8.
[56] Moigno, F.-N. (1852). *Cosmos* 1, pp. iii-iv, 1-3, and (1854). "Avis". *Cosmos* 5 (18 août): 201-2.
[57] Mannoni, L. (1995). *Le grand art de la lumière et de l'ombre. Archéologie du cinema*. Paris: Nathan, pp. 249-57.
[58] Advertisement inserted in Ganot. *Cours*. (1859).
[59] Simon "Circumventing the 'elusive quarries' of Popular Science".
[60] Most French scholarship has focused on Franco-German cases, but the international dimension of the Parisian book trade was larger, including booksellers of other nationalities such as Spanish, Italian or Swedish. Kratz, I. (1992). "Libraires et Éditeurs Allemands installés à Paris, 1840-1914". *Revue de synthèse* 1-2: 99-108; Barbier, F. (1988). "Les échanges de librairie entre la France et l'Allemagne, 1840-1914". In Espagne, M. and Werner, M., eds. *Transferts: les*

relations interculturelles dans l'espace franco-allemand (XVIIIe et XIXe siècle). Paris: Editions Recherche sur les civilisations, pp. 231-60.
[61] Caron, J.-C. (1991). *Générations romantiques, les étudiants de Paris et le Quartier latin, 1814-1851*. Paris: A. Colin; Desmond, A. (1989). *The Politics of Evolution.* Chicago: The University of Chicago Press; Warner, J. H. (1998). *Against the Spirit of System. The French Impulse in Nineteenth-Century American Medicine*. Baltimore: The Johns Hopkins University Press.
[62] Barber, G., ed. (1994). "Treuttel and Würtz: Some Aspects of the Importation of Books from France c. 1825". *Studies in the Booktrade of the European Enlightenment*. London: The Pindar Press, pp. 345-352, on p. 381; Barbier, F. (1981). "Le commerce international de la librarie française au XIXe siècle". *Revue d'Histoire Moderne et Contemporaine* 27: 94-117; Martin, O. and Martin, H. J. (1985). "Le monde des éditeurs". In Martin, H. J., ed. *Histoire de l'édition française*. Paris: Promodis, pp. 159-215, on pp. 172, 176; Feather, J. (1994). *Publishing, Piracy and Politics. An Historical Study of Copyright in Britain*. London: Mansell.
[63] Simon, J. (2008). "The Baillières: The Franco-British Book Trade and the Transit of Knowledge". In Fox, R., and Joly, B., eds. *Franco-British interactions in science since the seventeenth century*. Paris: Vuibert.
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[83] The English editions of Ganot's books were reprinted in the USA and were also used in countries such as India and Japan.
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[87] Ganot sent–at least in certain occasions–a copy of his book to its English publisher, in order to help the work of the translator, and apparently, he was regularly sending engraving stereotypes for each new edition. Archive of the House of Longmans, *Atkinson File*.
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[89] *Preface* in Ganot (1875). *Treatise*.
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[91] Its second edition (1875) had a print-run of 5,000 copies and sold around 2,600 copies in the first seven months. The print-run of the third edition (1878) increased

to 7,000 copies and the fourth (1881) and fifth (1884) attained 9,000 and 10,000 copies respectively. Archive of the House of Longmans, *Atkinson File*.

[92] As previously pinpointed Fleck's concept of 'vademecum' helps us to understand the fact that the *Traité* was a closed organized system.

[93] "Preface" in Ganot (1872). *Natural Philosophy*.

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