The origins of a mathematical heritage: The library of Gaston Darboux's cabinet of Higher Geometry (1900–1917)

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ABSTRACT

Between 1900 and 1917, Gaston Darboux (1842-1917) built up a library associated with his Chair in Higher Geometry at the Paris Faculty of Science, which forms the initial nucleus of today's library at the Institut Henri Poincaré, inaugurated in 1928. Created in the wake of a series of reforms instituting a new university system in France, this library serves not only as a current working tool for his teaching and research activities, but also as a testimony to the mathematics of his time.

This article[1] focuses on the origins of the library of the Institut Henri Poincaré (IHP), which still exists today, and the process by which mathematics has become part of its heritage. Built in 1928 (Cléry, 2020), the IHP building housed the Department of Mathematical Sciences of the Paris Faculty of Sciences, providing professors and students with new offices, two new lecture halls and a library. In the archives stored there, we found a document tracing the history of this library, dated April 1, 1933[2]:

> Gaston Darboux, Perpetual Secretary of the Academy of Sciences and a proponent of library specialization, which he felt was becoming a necessity, had initiated the creation of a library specialized in pure mathematics, in the Cabinet of Higher Geometry[3] he held at the Sorbonne. Here, he brought together the works that his chair's budget allowed him to acquire, as well as a large number of those he received personally.
>
> In 1915, he asked Pierre Gauja to put the library in order, to draw up a catalog and to point out any gaps.
>
> When he died, Paul Appell, then Dean of the Faculty of Sciences, felt that the interest of this library went beyond the scope of the Chair of Higher Geometry, and wanted to give it a life of its own. To this end, he grouped together the chairs of mathematics and mechanics, assigned to them Gaston Darboux's cabinet, along with its library, which thus became that of the Cabinet of the Department of Mathematical Sciences of the Faculty of Sciences, and allocated a certain amount of credit to this cabinet for acquisitions and bindings.
>
> [...]
>
> Paul Appell's work was enlarged, in 1928, by M. Emile Borel, who had obtained donations from the Rockefeller Foundation and Baron Edmond de Rotschild that enabled the Institut Henri Poincaré to be built on rue Pierre Curie. The chairs of the Department of Mathematical Sciences, in which probability calculus was given greater prominence, and those of mathematical physics were installed there.

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[1] This research was carried out as part of a postdoctoral contract funded by the Agence Nationale de la Recherche project PatriMaths (ANR-21-CE27-0022-03): https://patrimaths.fr.

[2] All translations from French to English are mine.

[3] In French : "Cabinet de géométrie supérieure".

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> Quite naturally, the library of the Cabinet of the Department of Mathematical Sciences, brought from the Sorbonne, became that of the Institut Henri Poincaré. The library's specialization remained the same, but it started to include mathematical theories of physics.

This testimony by Pierre Gauja (1886–1969), secretary-archivist of the Paris Academy of Science between 1915 and 1949, thus claims that the library built up by Gaston Darboux (1842–1917) was the initial nucleus of the IHP library. More precisely, Gauja states three key points that we wish to subject to historical analysis. First, he states that the library was created at the Faculty of Sciences by Darboux, without specifying a date. Second, the creation of this library was motivated by Darboux's belief in the need for library specialization. Third, that Darboux himself setted up a library specialized in pure mathematics. Professor of higher geometry at the Paris Faculty of Sciences between 1881 and 1917, Gaston Darboux is best known for his work in geometry and analysis, or for his role as editor of the *Bulletin des sciences mathématiques* [4]. As for Gauja's testimony, we are interested in this mathematician for the library he built up at the Paris Faculty of Sciences in the early years of the 20th century.

Our initial research in the minutes of the councils and assemblies of the Faculty of Sciences (Archives nationales, AJ/16/5121-5123) and the University of Paris (AN, AJ/16/2553-2590) between 1881 and 1917 proved fruitless: there was no mention of the creation of the library (nor of the cabinet, for that matter) of higher geometry, nor of Darboux's possible motivations. In fact, the first mention we found of this library dates from 1918, when Appell gave it the status of library of the Department of Mathematical Sciences of the Paris Faculty of Sciences.

Lacking documentation on the creation of this library, we pursued an indirect approach by seeking to identify what within the context of this Chair of Higher Geometry might have prompted and allowed Darboux to establish a library. To this end, our research proceeded in three directions: first, from a biographical perspective, we examined Darboux's career; second, from an institutional perspective, we analysed the policies affecting faculties of sciences in France at the turn of the century; and third, from an architectural perspective, we studied the buildings of the Sorbonne. Through this, we sought to identify Darboux's possible motivations and conception of such a library.

We then compared these possible motivations with the acquisition practices within this library. Using an inventory book, we carried out a quantitative analysis to shed light on the underlying logic in the formation of this collection, and the role played by Darboux in this acquisition process. We also considered the patrimonial question. We therefore sought to determine the place given to old documents, the value of this library and, above all, the initial conditions of the transmission and conservation processes undertaken after Darboux's death in 1917.

1. A mathematical library in the shadow of a man of action at a time of transformation

Gaston Darboux was one of the key figure of a major shift in the French scientific and academic world in the last third of the 19th century. Since its establishment in 1794, the École polytechnique had dominated the scientific and higher education landscape in France. Darboux embodied, for mathematics, the leading figure of a movement that saw the École normale supérieure (ENS) rise to the forefront of the French scientific and academic scene. Darboux's career illustrates the gradual takeover on mathematical research and university teaching of mathematics, which would be amplified by future generations of mathematicians trained at the ENS. While Darboux's institutional career attracted the attention of his contemporaries (Lebon, 1910; Lippmann et al., 1912; Picard, 1917a,b; Baillaud, 1917; Dehérain, 1917; Anonyme, 1917; Picard, 1919), his actions regarding the material conditions of mathematical activity, particularly libraries, have still been little explored by historians, with the important exception of his role as editor of the *Bulletin des sciences mathématiques* (Gispert, 1987; Croizat, 2016).

1.1. A career spanning two centuries: the rise of a mathematician from the École Normale Supérieure

Jean Gaston Darboux was born on August 14, 1842 in Nîmes, Gard[5]. He ranked first in the competitive examinations for the École polytechnique and the ENS. In an unprecedented decision, the young Darboux chose to continue his education at the latter between 1861 and 1864[6]. On September 26, 1864, he was appointed *agrégé-préparateur* at the ENS. This position had just been created for him, at the request of the ENS director Louis Pasteur (1822–1895), who saw in this young man a future great mathematician. That same year, Pasteur secured the creation of a science library at the ENS and entrusted Darboux with its management for two years.

Darboux completed his studies at the ENS in 1866, and began his career as a substitute for Joseph Bertrand (1822–1900) at the Collège de France for the academic year 1866–1867. Between 1866 and 1872, Darboux remained at Paris, teaching in secondary school – which was the expected career destination for former students of the ENS. He first taught mathematics at the Collège Rollin between 1866 and 1868, then at the Lycée Louis-le-Grand, where he remained until 1872.

In 1868, Michel Chasles (1793–1880) took advantage of the creation of the École pratique des Hautes études (EPHE) in Paris to launch a journal of mathematical reviews, the *Bulletin des sciences mathématiques* inspired by the *Bulletin de Férussac*. Chasles asked Darboux to be one of its editors, and soon entrusted him with the leadership of the publication. This proximity to the EPHE enabled

[4] See Barnabé Croizat's thesis (Croizat, 2016) and François Plantade's thesis (Plantade, 2018) and references therein.

[5] The career we have reconstructed is based on his retirement settlement file (AN, F/17/23271/A) and his career file at the Paris Faculty of Sciences (AN, AJ/16/5946). These career files are summarized and completed in Charle and Telkès (1989).

[6] The student files for the classes of 1858 to 1869 do not appear to have been conserved in the Archives nationales.

Darboux to join its patronage committee in 1882, which he chaired in 1901 (AN F/17/13616). This appointment also reflected Darboux's growing career in higher education.

His career in higher education began in 1872 when he was appointed lecturer in differential and integral calculus at the ENS. The following year, he became a lecturer in mathematics, replacing Charles Hermite (1822–1901). At the same time, Darboux joined the Paris Faculty of Sciences. In 1872, he was appointed substitute for Joseph Liouville (1809–1882) at the Chair of Rational Mechanics, a position he held until the end of the 1877–1878 academic year. Over the next three academic years, he was appointed substitute for Michel Chasles (1793–1880) at the Chair of Higher Geometry. After Chasles' death, Darboux was first appointed lecturer in Higher Geometry on December 28, 1880, then full professor on April 9. He remained in this position until his death on February 3, 1917.

Darboux's involvement in university scientific policy intensified after 1889. Between 1889 and 1903, Darboux was Dean of the Faculty of Sciences[7]. Darboux was subsequently appointed to the *Conseil supérieur de l'Instruction publique*, an advisory board to the Minister of Public Instruction. He served as a member between 1888 and 1904 and as a permanent member from 1896 to 1904. He was reappointed member in 1907, became vice-president in 1908, and remained a permanent member from that year forward. In 1902, he was also appointed to the technical commission of the *Caisse de Recherche Scientifique*, created in 1901. Additionally, he held positions in numerous scientific institutions including the Paris Observatory Council from 1892, the Meudon Observatory Council from 1899, the *Bureau des Longitudes* from 1902 and the *Bureau National des Poids et Mesures* from 1907.

Suffering from illness, he died on February 23, 1917 at the age of 75.

1.2. *A man of action in a time of transition*

The historical sources (tributes, obituaries, biographies) we consulted particularly highlight Darboux as an administrator and a man of action. Darboux himself reflected on his tenure as Dean of the Paris Faculty of Sciences during his Jubilee at the Sorbonne in 1912:

> Having come at a time of transition, when higher education formed an inorganic whole, when scientific research was left to the whim of private initiatives, I now see it well organized, ready to face the legitimate demands of a great nation. If, in my modest role, I have been able to contribute to the great work that has been accomplished, I am happy to acknowledge that those around me and those who will soon replace me have gone or will go much further than I have. To conclude, I have only one wish: that in their turn and for the good of the country, they may render the same justice to those who will be called upon to succeed them (Lippmann et al., 1912, p. 125).

On the occasion of this jubilee, as well as in obituaries or biographies of contemporaries, speeches systematically mentioned Darboux's years as Dean of the Paris Faculty of Sciences amid a period of profound and multiple reforms. His knowledge of the history of public education, his talent for negotiation, particularly in securing new scientific laboratories at the newly built Sorbonne, were frequently highlighted. Additionally, his role as perpetual secretary of the Academy of Science and his involvement in the "Societé de secours des amis des sciences" (The Friends of Science Relief Society, which provides financial assistance to families of deceased scientists experiencing financial hardship), were often mentioned. More recently, historians have also drawn attention to Darboux's role in the (slow, difficult, partial) institutionalization of scientific research in France between the end of the 19th century and the beginning of the 20th century [8].

This talent as a man of action seeking to develop mathematical research was particularly evident in his role as editor of the *Bulletin des sciences mathématiques*. Early letters from his correspondence with another editor of the *Bulletin*, Jules Houël (1823–1886), edited by Hélène Gispert (1987), as well as the research carried out by Barnabé Croizat (2016) and François Plantade (2018), highlight that this periodical was conceived as a tool for the revitalization of French mathematics, notably by combating an inward-looking attitude through the publication of reviews of European mathematical works. Moreover, as Barnabé Croizat shows, Darboux's review work was an integrated part of his personal research activity, at least until 1878. Most importantly, historical studies reveal the difficulties and the importance Darboux placed on accessing contemporary and international mathematical literature.

1.3. *The mathematical misery of Parisian libraries*

Libraries should have provided privileged access to such literature. Yet Darboux's relationship with libraries is poorly documented. Apart from the anecdote of his father's library, containing Darboux's favorite book, *Don Quichotte*, his assignment to the ENS scientific library is mentioned but without any details on his actual activity there (Lebon, 1910; Croizat, 2016).

Only one letter from Darboux to Hoüel gives insight into his view on Parisian libraries. Actually, he expressed his dismay without ambiguity:

[7] He was elected for a three-year term in 1889 with 24 votes out of 33 cast. Clearly appreciated as dean, he was unanimously re-elected in 1892, again in 1895, and came close to unanimity in 1898 (35 votes out of 36) and 1901 (35 votes out of 37). Darboux did not complete his final term and asked to resign in 1903. He cited his duties at the Academy of Sciences, where he had been elected to the geometry section on March 3, 1884, then perpetual secretary in 1900. His resignation was immediately accepted by the Minister of Public Instruction, who appointed him honorary dean on the same day, at the suggestion of the faculty.

[8] See Croizat (2016) and the bibliography below.

> Incredible as it may, here in Paris there is not a single library where one can consult all the important collections. If I want to read a journal, I have to subscribe to it. At the Bibliothèque impériale[9], even at the Institut[10], it is difficult to obtain the best-known periodicals, especially the latest volumes; they're always in the bookbinder's, or the librarians don't want to bother. Sometimes I go there to ask for well-known journals, such as *Cambridge and Mathematical* (*sic*) , but they do not have a complete collection. Like you, I receive the *Zeitschrift*, the *Annales de Clebsch*, those of Brioschi, the *Archives de Grünert*, of Crelle, but I have neither the Danish journals, nor that of Naples, nor the *Bulletin du prince de Boncompagni* (Gispert, 1987, p. 89).

This undated letter from early 1870 indicates that, faced with the difficulties of consulting contemporary and international mathematical literature in Parisian libraries, Darboux resigned himself to acquiring these documents personally. It should be noted that the context of these letters suggests that the *Bulletin des sciences mathématiques* both stimulated and heightened the urgency of accessing such documentation.

The frustration expressed by Darboux in this letter regarding access to a collective library containing a collection of mathematical documents useful for research, may thus have motivated the creation of a library within the Paris Faculty of Sciences. However, the sources we have consulted simply do not mention such a library.

2. A new university for Paris: teaching specialization and the injunction to research in the reforms of the Third Republic

The creation of the library within the Cabinet of Higher Geometry by Gaston Darboux, whose inventory began in 1900, was part of a profound transformation of the Paris Faculty of Sciences. This transformation took place in a context of national-scale reforms implemented between 1870 and 1904[11]. We will focus on elements that likely influenced the activities of Darboux's Chair of Higher Geometry, drawing on legislative, regulatory, and administrative texts on higher education from 1793 to 1915 (de Beauchamp, 1880, 1882, 1884, 1889; Générès, 1898, 1909, 1915). Based on this corpus, we tried to understand how Darboux's creation of a library was a response to the educational reforms of the early Third Republic (1870–1940).

By first studying the evolution of institutional structures, we seek to understand how these reforms could make it possible for Darboux to take a personal initiative that would not necessitate formal authorization. Secondly, given that the conferring of State degrees (*baccalauréat*, *licence*, *doctorat*) was the sole purpose of faculties in France throughout the 19th century, we seek to understand how the reforms of the *licence ès sciences* and the *doctorat ès sciences* during this century could have created the need for Darboux to set up a library at the Paris Faculty of Sciences.

2.1. The creation of a new university system (1870–1896)

The reforms carried out under the Third Republic between 1870 and 1896 led to an overhaul of the university system set up in 1808, and gave birth to a new system of higher education that was to remain unchanged throughout the Third and even Fourth Republics (1946–1958). Following the suppression of the faculties of the Ancien Régime in 1793, the decree of March 17, 1808 established five categories of faculties (theology, medicine, law, letters and sciences) with a monopoly on the conferring of degrees (*baccalauréat*, *licence*, *doctorat*). These faculties coexisted independently of one another, and were unevenly distributed across the French territory, which was divided into *académies*[12]; without any autonomy, they were subjected to the control and supervision of the central administration, notably regarding appointment, curricula, and discipline matters (Luc et al., 2020, p. 83–94).

The reforms following the proclamation of the Third Republic aimed, in one and the same movement, to reconstitute universities, defined as the grouping together of faculties of all kinds within an *académie*, to strengthen their local ties, by enabling collaboration with local political and economic authorities, and to organize their autonomy, by delegating to them prerogatives of the State[13]. The strategy involved fostering collegiality both between and within faculties. In 1872, a ministerial circular dated November 10 instituted monthly meetings of deans under the chairmanship of the *Recteur* of the *Académie*[14]. The aim of these meetings was to coordinate teaching between faculties, to minimize redundancy and thus encourage students mobility between faculties. The same circular instituted meetings of professors from each faculty, chaired by the dean, to discuss curricula. This first circular thus encouraged a concerted and growing specialization of faculties, and even moreso of the teaching of each chair, always subject to State control.

This collegiality was reinforced by a decree dated July 25, 1885 (de Beauchamp, 1889, p. 93–97). This decree followed a survey carried out in 1883 by the Minister of Public Instruction, Jules Ferry (1832–1893), explicitly aimed at advancing the autonomy of universities. The meeting of deans was transformed into a General Council of Faculties, responsible for administrative, financial, pedagogical and disciplinary matters. The meeting of professors was split into a Faculty Council, bringing together full professors to discuss the faculty's administrative and financial issues, and a Faculty Assembly, which included all teachers and focused on pedagogical issues. According to the Minister of Public Instruction René Goblet (1828–1905), the aim of these measures was to

[9] Today's Bibliothèque nationale de France or BNF.

[10] Today's Institut de France where the Bibliothèque Mazarine is located.

[11] On university reforms, see Prost (1970), Weisz (1983), Verger (1986), Charle (1994), Mayeur (2004) and Luc et al. (2020); on the effects of these reforms on university mathematics (teachers and publications), see Gispert (1989).

[12] In 1814, only 10 faculties of science were open, reduced to 7 in 1815, compared with 23 faculties of letters, reduced to 6 in 1815.

[13] On the roots of these reforms, see in particular (Mayeur, 2004) and (Prost, 1970).

[14] These meetings were planned in 1854, but soon fell into disuse. See (de Beauchamp, 1882, p. 831–833).

"develop in the faculties, freedom, a spirit of initiative and solidarity" (de Beauchamp, 1889, p. 203). The law of July 10, 1896 officially gave the title *université*, represented by their General Council of Faculties, to the groups of faculties of a same *académie*.

In addition, the decree of July 25, 1885 (de Beauchamp, 1889, p. 93–97), followed by the budget law of 1893 (Générès, 1898, p. 247), granted legal personality to faculties and groups of faculties respectively. This legal personality allowed them to receive donations and legacies from private individuals, as well as subsidies from local political authorities and companies. This facilitated the specialization of faculties, particularly in sciences, based on their local economic and industrial contexts, and enabled them to have their initiatives financed without increasing the financial burden on the State[15].

The creation of a library by Darboux, presumably in 1900, took place in the wake of reforms intended to encourage collective and individual intiatives within faculties that were granted significant autonomy. While partnerships with local political and economic authorities enabled the development of idiosyncratic forms of faculties of science, geographical distinction was also based on a reform of the *licence ès sciences*, also carried out in 1896.

2.2. The reform of the licence ès sciences (1896): from general to specialized scientific teaching

The reform of the *licence ès sciences* in 1896 profoundly changed the nature of this degree. Created in 1808, the *licence ès sciences* was theoretically the necessary (but not sufficient) degree for entering the teaching profession (de Beauchamp, 1880, p. 216–218). Divided into three branches of science (mathematics, physics and natural sciences) in 1810, this degree struggled to balance the requirement for a broad scientific education expected of a secondary school teacher with the need for disciplinary specialization. Initially designed as an examination in differential and integral calculus and in mechanics, the *licence ès sciences mathématiques*, like the other two *licences ès sciences*, was assigned a demanding national syllabus in 1853. Aspiring teachers were required to succeed in three eliminatory tests (written, practical and oral), and to obtain two *licences* (de Beauchamp, 1882, p. 273–277).

In the same spirit, the decree of January 22, 1896 (Générès, 1898, p. 558–567) instituted an intermediate diploma between the *baccalauréat* (the degree required for passing the *licence*) and the *licence ès sciences* with the creation of the *certificats d'études supérieures* (certificates of higher studies). It also modified the awarding process of the *licence*, which was now granted after passing three such *certificats*. The curriculum was no longer defined by the Ministry. With the abolition of *licence* examinations, the subjects covered by each *certificat*, and even moreso each course, were defined locally by the professors. Moreover, students were free to choose which *certificats* they wished to take. Therefore, the *licence* diploma became organically unified, but was intended to represent an individual course of study within the faculty and, as Darboux mentioned in the report he presented on behalf of the *Conseil Supérieur de l'Instruction Publique* (Générès, 1898, p. 559–561), to open up new professional outlets, particularly in industry. This radical change was nevertheless tempered for aspiring secondary school teachers, whom choices of *certificats* were restricted, at least for the first three. Those intending to teach mathematics were required to obtain a *certificat* in differential and integral calculus, as well as one in mechanics, continuing a conception of mathematical culture established at the beginning of the 19th century. The third *certificat* could be chosen from those in the field of mathematics.

This trend towards specialization, linked to a desire to develop localized university models and broaden the professional opportunities for graduates took a second step forward in 1904 with the creation of *diplômes d'études supérieures* by decree of June 18. This decree created an intermediate diploma between the *licence* and the *doctorat*. Candidates were expected to present an oral paper based on a scientific paper or part of a course. This diploma was intended to encourage students' intellectual initiative, potentially leading to original research and allowing professors to identify strong doctoral candidates.

In mathematics – the only discipline explicitly adressed by the 1904 decree – the creation of this *diplôme d'études supérieures* in fact led to a hierarchy among the *certificats*. *Certificats* in higher geometry, higher analysis, mathematical physics, celestial mechanics and physical and experimental mechanics were considered as equivalent to the *diplôme d'études supérieures* in mathematics. In this way, mathematics *certificats* could be divided into two groups: those preparing students for the *licence* (differential and integral calculus, rational mechanics) and those preparing them for the *doctorat* (i.e. equivalent to the *diplôme d'études supérieures*). This exception granted to the mathematical sciences undoubtedly formalized an existing reality. In any case, this new context certainly encouraged professors teaching these second category of *certificats*, such as Darboux, to further specialize their content, which was furthermore now fully determined by the professor and no longer constrained by a national *licence* curriculum. This likely necessitated access to cutting-edge mathematical literature.

2.3. The affirmation of research as a mission for faculties of science (1880–1898)

The creation of the *diplôme d'études supérieures* also signaled a commitment to making research an integral activity of faculties of science. Successive ministers under the Third Republic made research a mission of the faculties, and even a duty to the State. Research appeared to be an imperative, first and foremost at the level of the *doctorat ès sciences*. In a circular dated May 8, 1880 (de Beauchamp, 1884, p. 461), the Minister demanded that only theses presenting new facts would be allowed to be defended, and called for the rejection of those that did not. Also created in 1808, the *doctorat ès sciences* was divided into three orders of science, and the *doctorat ès sciences mathematiques* was initially designed as the defense of two thesis on mechanics and on astronomy. The decree of June 8, 1848 (de Beauchamp, 1882, p. 46–47) had already introduced the notion of scientific discovery as a criterion for

[15] See, for example, the case of Nancy: (Rollet and Choffel-Mailfert, 2007). See also, on the case of Grenoble and Toulouse and the role of local personalities : (Prost, 2007, p. 153–156).

the *doctorat ès sciences*, though it remained optional for mathematics, unlike for physical and natural sciences. The 1880 ministerial circular therefore aimed to make the presence of scientific discoveries mandatory, and established a dual requirement for mathematics: candidates had to defend both original research and a topic assigned by the jury.

Incidentally, as the 1880 circular made clear, the requirement for new scientific facts in theses necessitated a jury capable of identifying, evaluating and discussing them. In this circular, the Minister of Public Instruction required that the choice of jury be guided by the competence of its members, authorizing the deans to call on professors from other faculties[16]. Since at least 1810, professors had been obliged to “follow and study new discoveries made in the sciences, so that teaching is always up to date with acquired knowledge” (de Beauchamp, 1880, p. 249), and in 1880, the requirements of the *doctorat* made this obligation more constraining.

The reinforcement of research as a faculty mission was addressed more directly to professors in a circular dated February 18, 1883 (de Beauchamp, 1884, p. 705–706). The Minister of Public Instruction urged them to publish their research and to train young people for research. The Minister refrained from prescribing the means to be used to achieve this. He relied on personal initiative, which he asked not to be discouraged, and specified that the administration will support “all good will” and that “its role is to follow the innovators and embolden them if they hesitate”.

Darboux’s report on the *doctorat* reform of 1898 (Générès, 1898, p. 787–789), which aimed at bringing it into line with the *licence* reformed two years earlier, also affirmed research as the mission of the faculty. In it, Darboux emphasized that the doctoral examination “must above all encourage and highlight the spirit of invention, the aptitude for those scientific investigations which constitute the true function of higher education”. As *rapporteur* for the *Conseil Supérieur de l’Instruction Publique*, Darboux thus became the spokesman for a policy that sought to make research an organic function of faculties of science.

The creation of the library of higher geometry closely followed a series of reforms establishing a new university system. This new system was based on local autonomy for faculties, encouragement for individual initiative, increased specialization of teaching, particularly for the Chair of Higher Geometry, and the affirmation of research as a central activity of faculties. As the spokeman for the *Conseil Supérieur de l’Instruction Publique*, Darboux advocated these reforms to the political authorities. Under these circumstances, the need for access to contemporary and international literature likely became increasingly urgent for Darboux, both for preparing his lectures and conducting his research. The successive ministers of the 1880s and 1890s refrained from prescribing specific material resources to implement these reforms. In Paris, these material resources came to the fore during the reconstruction of the Sorbonne.

3. A new Sorbonne for the University of Paris: mathematics in Nénot’s Sorbonne

The university reforms undertaken by the French republicans in the last two decades of the 19th century also took an architectural dimension. University construction projects, co-financed by the State and local municipalities, were launched all over France (Bordeaux, Lille, Lyon, Marseille, Montpellier, Nancy, Toulouse…). These university buildings did not follow a predetermined pattern, but were adapted to local conditions. In Paris, reconstruction of the Sorbonne began in 1881, and immediately took on a singular turn, integrating both political and scientific imperatives.

While the physical, chemical and natural sciences received most of the attention, the place of mathematics in these new premises is difficult to document: only three letters explicitly mention mathematics facilities. This lack of archival evidence indirectly reveals the minimal space allocated to mathematical research in the old Sorbonne buildings. As Dean of the Faculty of Sciences during the construction of the buildings meant to house its teaching and research facilities, Darboux was in a prime position to assess the extent to which mathematics was lagging behind other sciences in terms of research infrastructure and to attempt to change this situation.

3.1. A palace for the Sorbonne: constrained but symbolic choices

Launched in 1881, the reconstruction of the Sorbonne took place *in situ*, on the historic site of Collège Sorbon, its ancestor founded by Robert de Sorbon in 1253[17]. This choice had considerable financial consequences: the costs to be incurred for demolition, reconstruction and relocation exceeded 30 million francs[18], more than two and a half times the ordinary budget of the faculties in 1880[19]. This choice also posed a major challenge, that of space. At the heart of Paris, confined between rue de la Sorbonne, rue des Écoles, rue Saint-Jacques and rue Cujas, the New Sorbonne immediately faced the limitations on its expansion. In fact, even before the construction was completed in 1901, space had already became scarce, leading to a migration process that continued until the 1930s.

The decision to rebuild *in situ* first reflected the identification of a place (the Sorbonne) with a group of institutions, including the Faculty of Sciences, dating back to 1821. The buildings had been transformed into artists’ residences following the abolition of the faculties in 1793. In 1821, the Minister of Public Instruction reinstated academic services, including the faculties of science, letters and theology within the Sorbonne buildings. As space became scarce over time, reconstruction projects were considered but never carried out, and extensions were simply made in a haphazard fashion. The French republicans who came to power in 1879 immediately positioned public education, particularly higher education, as a tool for reinforcing and legitimizing the republican regime. In Paris,

[16] In 1808, theses were defended before the entire faculty, before being defended before a jury of six faculty members in 1827. This jury was finally reduced to three members in the regulations of July 15, 1877; (de Beauchamp, 1884, p. 157).

[17] On the reconstruction of the Sorbonne, see Rivé (1987) and Hottin (2015).

[18] Louis Liard estimated the final cost of reconstruction at 32,200,000 francs, (Liard, 1909, p. 98–99).

[19] The ordinary budget of the faculties was estimated at 12 million francs in 1880, (Luc et al., 2020, p. 122).

the reconstruction of the Sorbonne was a highly symbolic undertaking: the Republic had to succeed where the monarchical and imperial regimes had failed.

The patriotic dimension of such a project was also important. First and foremost, by choosing to rebuild *in situ*, the aim was to inscribe what would soon become the University of Paris within a long, albeit obviously fictitious, history. What is more, the defeat of France in 1870 ending the Franco-Prussian war was seen as a humiliation and largely blamed on France's scientific backwardness. The reconstruction of the Sorbonne therefore sought to renovate the scientific infrastructure that would enable France to catch up with Germany. Drawing lessons from the qualities of the German university system, the new Sorbonne buildings were designed to integrate research into the faculties (especially those of sciences) by providing them with dedicated architectural spaces.

The choice to house several academic institutions within a single building was not an obvious one. In fact, in the aftermath of the 1870 defeat, discussions took place about relocating the Faculty of Sciences, either entirelly or partially to new buildings outside the Sorbonne, in the Jardin du Luxembourg. The final choice was in line with a policy of bringing faculties closer together, leading to the creation of universities. The aim was to give a "palace" to what would become the University of Paris. However, the project was immediately limited: only the faculties of letters and sciences moved in[20].

3.2. Mathematics in the project for a new Sorbonne (1881–1882)

In this context, which was so favorable to the production of archives, mathe- matics stands out for its discretion. Despite the abundance of archival records generated by the reconstruction process, mathematics remains notably absent. Very few archives document the place desired and ultimately granted to mathematics, or the need for facilities. Archives concerning mathematics are so rare that historians simply do not mention them (Rivé, 1987; Hottin, 2015). However, the construction project, which lasted from 1884 to 1901, was a titanic undertaking, generating a multitude of letters mainly from professors, deans, the *Recteur* and the architect.

The Sorbonne reconstruction officially began in the summer of 1881. After receiving political approval[21], the *Préfet* of the Seine department (the State representative of the department of the Seine) launched a survey on August 18, which served as the basis for the competition program approved by the jury on April 19, 1882. The winner of the competition was a young architect, Henri-Paul Nénot (1853–1934) who, at just 29 years old, had no prior major projects to his name but had won the prestigious *Prix de Rome* in architecture five years earlier.

The 1882 competition program called for three amphitheaters for the Department of Mathematical Sciences, with capacity for 120, 70 and 35 students respectively, each with an adjacent office. Additionally, six rooms were designated for teaching purposes. A gallery for models was planned near the second amphitheater, and a room for astronomical instruments was situated near the largest amphitheater. The requests therefore only mentioned facilities for teaching purposes[22]. The Department of Mathematical Sciences moved into its new premises, built during the third and final phase of the construction[23], at the start of the 1897 academic year. They were housed on the third floor of the building along rue Saint-Jacques.

3.3. Laboratory libraries in the new Sorbonne: an essential tool for scientific work (1893–1894)

Elected in 1889, Dean Gaston Darboux was a key figure for equipping the scientific services in the second and third phases of construction. On November 14, 1893, in a letter addressed to the *Recteur* (AN, 20030410/71), the Minister of Public Instruction reacted to the material needs (instruments, furniture, machines) expressed for the installation of laboratories in the Faculty of Sciences. The Minister made a number of criticisms, but his strongest reaction was about the laboratory libraries, which he considered too numerous and overstocked:

> I fully accept the existence of laboratory libraries as a necessity for the work of teachers and students, but on condition that they are not multiplied excessively, and that they do not take on an abnormal extension. I have reason to fear, from what appears in the proposals, that their number will be excessive, and that they will be given too much importance. I don't just see them for each order of science: physics, chemistry, zoology, etc. I see them in the premises allocated to each teacher, sometimes even to each lecturer. On the other hand, while in some cases the dimensions of the furniture requested do not seem excessive, in other cases they seem to have been designed for 8 or 10,000 volumes, sometimes even more.

Darboux responded with a survey conducted in early 1894, the results of which he sent to the *Recteur* of Paris on April 11, 1894. He counted 15 laboratory libraries, in fact one per chair, covering physics, chemistry and natural sciences[24]. Apart from the

[20] The faculties of law and medicine remained in buildings that had been renovated and extended to suit their needs. The Faculty of Theology was abolished as part of the secularization of public education that began in the 1880s.

[21] The project was adopted by the Paris City Council on June 30, 1881, by the Chamber of Deputies on July 26, and by the Senate on July 29.

[22] On the use of models in higher education, see Brechenmacher (2022).

[23] The first phase took place between September 1884 and August 1889. It involved construction of the building overlooking rue des Écoles, between rue Saint Jacques and rue de la Sorbonne, to the north. The second phase took place between December 1888 and January 1895. This involved construction of the buildings to the south, between the chapel and rue Cujas. These buildings were to house most of the physical, chemical and natural sciences departments. The third phase took place between 1893 and 1898. It involved the construction of two buildings linking the two previous buildings, around the main courtyard, along rue Saint-Jacques and rue de La Sorbonne respectively.

[24] AN, 20030410/7, reconstruction et agrandissement de la Sorbonne, 1ère partie, dossier no 22, 24.

biological chemistry library which contained no documents at all, the libraries held several hundred volumes (the anatomy library held only 72 volumes, the geology library held 2,670 volumes and 3,650 booklets), all subscribed to periodicals, and all received donated documents. Darboux stated that the survey concerned "the various laboratory libraries owned by the Faculty of Sciences". And indeed, the survey was not strictly confined to the laboratories due to be set up in the second phase of the works : the survey also covered the botany laboratory, which was due to be set up in the third phase, as was mathematics. However, mathematics was notably absent from this survey, suggesting that no dedicated mathematics library existed at the time. In this report, the gap between mathematics and the other sciences in terms of material resources for research appears to be total, and perhaps points to the prevalence of the personal and private library model for mathematicians.

In this report, Darboux spoke out in favor of laboratory libraries, i.e. libraries attached to a chair. First of all, he stressed that such a library was a working tool created by a professor. He mentioned the constitution of "fake collections", i.e. compilations of offprints or booklets bound together by a professor, theses and journal collections. In addition to the need for daily research activity, Darboux mentioned that such documentation couldn't be found in the Sorbonne library due to the lack of scientific expertise of the chief librarian and the lack of material resources for this central library. Finally, Darboux added a financial argument: a significant proportion of the documents in these laboratory (i.e. chair) libraries was in fact donated by the authors or the professor, which reduced their cost. He concluded by stressing on the need to leave "as much initiative as possible to the professors, who are the only ones capable of determining which works [...] are really indispensable." An injunction perhaps addressed primarily to himself, in a context where no mathematics library seems to exist at the Sorbonne. A situation that the reconstruction of the Sorbonne could change.

3.4. *Nénot's lack of interest in spaces made invisible: premises for the Department of Mathematical Sciences*

Historians have noted Nénot's ability to be flexible, attentive to requests, but also firm about acceptable limits (Morelle, 1987). It must be said that the installation of the science departments was fraught with technical and material difficulties. The second phase of the work is well documented in the archives concerning the reconstruction of the Sorbonne (AN, 20030140/7-8). However, with regard to mathematics and its installation, the archives suggest that Nénot was perhaps less sensitive to the needs expressed by Darboux.

On November 13, 1895, Darboux wrote to the *Recteur* requesting the plans for the new buildings, already under construction since 1894. The letter does not conceal a certain annoyance, as his requests to the architect remained unanswered. Darboux was even surprised by this silence, describing Nénot as a cooperative interlocutor until then. The plans, received by the Dean in 1896, immediately sparked criticism regarding the spaces allocated to the mathematics and botany departments (AN, 20030410/8, no. 37–38). For mathematics, Darboux recalled the modesty of the requests and aknowledged that part of them had been met: the three amphitheaters. The problem arose for the model gallery and the mathematical instruments gallery:

> The architect, who had always led me to hope for a very adequate installation, is now proposing to us that, instead of this gallery, we simply use a room which is, strictly speaking, the antechamber of the department. Moreover, its surface area is far smaller than what we need and which we have requested. I cite as a reminder the attic corridor which serves as an exit to all the amphitheaters and which is unsuitable for the purpose we wish to achieve.
>
> The example of the École Polytechnique, which at the beginning of this century combined practical exercises with theoretical studies (even in mathematics), has been followed abroad, and all German universities have spacious galleries where students can come to study or even build models of geometry or kinematics. Mr. Schwarz, professor of mathematics in Berlin, asked me on his recent trip to see our collections, and I must say that the room assigned to us does not do us honor and is not suitable for display. It's smaller than the one we had in the old Sorbonne.

Darboux's criticism concerned the use of the space devoted to the models. Nénot had planned to use a corridor. Darboux argued that a corridor was not a place for practical work. The model room should be a work space for students, not a place to wander around. The gallery was also intended as a means of representing the quality of mathematics at the Sorbonne, especially in the eyes of visiting German mathematicians, a move that tugged at the heartstrings of revanchist patriotism. Finally, it is worth noting that Darboux made no mention of a library.

The architect's response arrived on June 4, 1896, and showed a lack of understanding of the criticism. Nénot merely listed the surface areas planned for the Department of Mathematical Sciences, pointing out that the sum was much higher than originaly requested in the competition. He gave no concrete answer regarding the model room. Darboux then took the discussion to the Faculty Council on June 6, 1896, and in his letter of June 8, stated its conclusion: the gallery of models was an indispensable tool for teaching mathematics at the Sorbonne and for maintaining it at the highest level. The exchange ends there in the archives, but no doubt a meeting was organized by the *Recteur* and changes were made.

More generally, Henri-Paul Nénot showed no particular interest in the design of spaces dedicated to mathematics, except for those related to astronomy. In a series of articles published in 1895[25], the only mention of mathematics were that this department was located on the third floor and was composed of three amphitheaters, for forty, sixty and one hundred and twenty students, with professors' offices and a large gallery of instruments, in direct communication with the astronomy tower on rue Saint-Jacques, at the

[25] Those articles were compiled the same year in a book, (Nénot, 1895a).

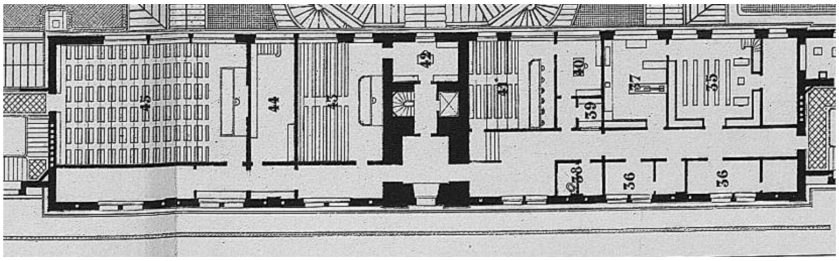

Fig. 1. Plan of the department of mathematical sciences from the *Monographie de la nouvelle Sorbonne* (1903) of Henri-Paul Nénot.

top of which will be installed a small equatorial with rotating dome, with a small meridian behind and slightly below, on the attic. And in the tower itself, a high room for pendulum experiments.

> The whole of this small observatory will have a mediocre stability, being directly on the street; but the professors agree in advance; because it is not a question of making serious observations, but simply of teaching the students of mathematics the handling of the apparatuses and instruments of astronomy (Nénot, 1895b, p. 412).

The construction of the observatory, an imposing architectural element, was well presented in a paragraph opposite its use, followed by a picture showing it. The observatory was presented in the same way as the architectural spaces devoted to the other physical, chemical and naturel sciences departments, which were also the subject of lengthy, richly illustrated explanations. Mathematics, on the other hand, didn't even get a full sentence. This 1895 book thus highlights how much the architect's attention was focused on the experimental or observational sciences, on their considerable and technically complex architectural needs, in comparison with which the needs expressed by mathematicians certainly seemed very banal and in any case unspectacular.

In his *Monographie de la nouvelle Sorbonne* published in 1903 (Nénot, 1903), Nénot presented plans (see Fig. 1) and a legend for each floor. Mathematics appeared only once: on the legend for the first floor plan, designating the "escalier des Hautes études et mathématiques" (stairs of the Higher Studies and mathematics). According to the legend on these plans, under the heading "Mécanique physique" (physical mecanics), the Department of Mathematical Sciences was indeed housed under the roofs on the third floor. There included the three mathematics amphitheaters, named Chasles (No. 41 on Fig. 1), Le Verrier (No. 43) and Cauchy (No. 45), a study room (No. 35), a laboratory (No. 37), four professors' offices (No. 36, 40 and 42), a cloakroom (No. 39) and (finally) a library (No. 44).

As an advocate of laboratory libraries as a research tool shaped by a professor, Darboux could only note the lack of development of material resources for mathematical research. It seems he managed to secure from the architect a room for a library within the architectural spaces dedicated to mathematics, but it was clearly designed as a storage space for documents rather than a reading area. This library certainly played a role in teaching, but also seemed to be a research tool, as a laboratory library. The completion of the work, which lasted until 1901, may explain why the build-up of a library on these premises did not begin until 1900.

4. The library of the chair of Higher Geometry in the new Sorbonne (1900–1917)

The formation of a collection of written documents within these architectural spaces is documented by three archives kept at the IHP library[26]: an inventory (covering the period 1900–1937), a repertory (undated) and a chronology of acquisitions (covering the period 1900–1952). The 189-page inventory lists all the acquisitions made by the Cabinet of Higher Geometry, in ascending order of inventory number. The untitled 58-page repertory contains minimal bibliographical references (author's name, title) arranged alphabetically by the author's last name. Finally, the chronology of acquisitions (2 pages) specifies the number of acquisitions and inventory number boundaries by year. These three documents raise a series of difficulties that are important to address, not only to understand their contents, but also to grasp the status of this library. Nonetheless, they make it possible to identify a corpus of book titles whose content we have sought to reveal through quantitative analysis. Finally, in 1917, this library became the starting point for a process of heritage preservation, the initial conditions of which we analyze.

4.1. Sources for documenting a library quantitatively

These documents first remind us that the formation of a collection of books and periodicals was part of a larger entity, initially called "Cabinet de géométrie supérieure" (Cabinet of Higher Geometry). As previously mentioned, we found no official trace of such a cabinet. To add to the confusion, the cover of the inventory bears a partially destroyed label on which "laboratoire de Mathématiques, Darboux" (mathematics laboratory, Darboux) can still be read. Futhermore, the contents of the first 1,066 entries in the inventory for the period 1900–1917 are rather eclectic. Office furniture and instruments account for 100 inventory numbers, geometric models for 28, books for 745, and journals for 169[27]. Additionally, the chronology of acquisitions between 1900 and 1952 is headed "Cabinet

[26] At present, these documents have not been assigned a classification mark.
[27] The analysis of the journal corpus and its comparison with the corpus of books identified is a work in progress.

du Département des sciences mathématiques" (Cabinet of the Department of Mathematical Sciences), confirming that the library was not conceived as an independent entity but as part of a larger one.

The inventory to which we had access presents challenges in terms of the quality of the information. We have not found the original inventory, but a reduced photographic reproduction which diminishes the readability of the handwritten entries. The original document itself would likely not have been much easier to work with: the small, tightly-packed handwriting poses recurring problems of legibility.

The repertory partially helped identify some of these illegible entries. It provides a legible author's name, title and, most importantly, the inventory number, enabling cross-referencing. This repertory covers printed documents only. The first inventory number in the repertory is No.20. However, this is not the first written document in the inventory: the very first, at No.2, is in fact an issue of the *Deutscher Universitäts-Kalender* of 1899, which, according to the inventory, was given to the secretariat (of the Faculty of Sciences) in 1903. This detail suggests that the repertory was started in 1903 at the earliest.

However, the repertory only contains information on documents that were in the inventory up to 1908. We were unable to identify 20 entries from 1909 onwards, and 57 over the whole period. It should be noted that the repertory is not an inventory at a fixed point in time. It was certainly started and completed over several years. In fact, although the repertory is organized alphabetically by author's name, this order is only consistently followed for the first letter of each name. For example, the name Bertrand appears on pages 3 and 4 before Bianchi, then on page 6 after Betti.

The existence of this repertory suggests certain uses related to the library and inventory keeping. Firstly, the repertory makes it possible to search for documents in the library by their author's name. Such a search is particularly laborious in an inventory arranged by ascending number. Secondly, this type of search is undoubtedly useful for drawing up the inventory. We don't know who was keeping the inventory, or by what procedure. Nevertheless, the multiplication of documents increased the risk of producing duplicate book entries, or multiple inventory numbers being assigned to a book or periodical title. The repertory may have been intended to minimize duplicates, but it did not prevent them, since we have identified 36 such duplicates.

Finally, the titles given are not the original titles of the books. Among these titles, we identified 634 corresponding to 652 inventory numbers (64.1 % of book entries). The remaining entries could not be confidently be associated with a title existing in the IHP catalog[28], the Sudoc (a common university documentation system)[29] or the catalog of the Bibliothèque nationale de France (BNF)[30], for lack of sufficiently precise and accurate information. In particular, dictionaries (33 entries) and theses (22) were excluded from analysis due to unusable title information. This corpus of 635 book titles has enabled us to carry out a quantitative study of the pace of acquisition, the contents of this library, the place of foreign mathematical production and the up-to-date nature of this collection.

4.2. The impetus of 1903 and the decline of the 1910s

The inventory contains few dates: only 1900, 1901, 1902, 1908, 1909, 1916 and 1917 are listed. We were therefore helped by the chronology of acquisitions in the archives. It is unclear on what basis this chronology was compiled, likely written in 1952, and it contains some anomalies: 40 volumes would have been added to the inventory in the year preceding that of their publication, and, above all, 2 volumes would have been added two years in advance. We have therefore corrected this chronology, so that no document is included before the year of publication.

In addition, the 634 titles identified correspond to 875 volumes. This number of volumes makes it possible to follow the pace of acquisitions in a material sense (Fig. 2). This chronology of acquisitions shows a massive influx of volumes in 1903, perhaps linked to Darboux's resignation from his position as Dean of the Faculty of Sciences, which further reinforces the hypothesis of a repertory begun in that year. During that year, 321 volumes (36.7 %) were added to the library. Most volumes were added between 1900 and 1909 (728 volumes, 83.2 %) at a rate fluctuating between 35 and 70 volumes annually from 1904 to 1909, then falling to between 21 and 40 over the next four years, and collapsing to between 1 and 6 from 1914 to 1917. Acquisitions came to a halt in 1914, probably due to the outbreak of the First World War, but possibly also due to a lack of space.

4.3. Mathematics in touch with its scientific, industrial and institutional context

Quantifying the contents of the books presents many challenges, and we have limited ourselves to estimating the themes present. The aim is to measure the range of contents represented in the corpus of 875 volumes. We have constructed the categories on the basis on lists of keywords present in the title, thus allowing the constitution of thematic sub-corpuses. We did not try to make an exhaustive classification (30 volumes were not classified) nor to form a partition of all 875 volumes (101 volumes were classified in several categories) which would have led to the multiplication of singletons (6 singletons were nevertheless identified) making their interpretation difficult. Nevertheless, this method allows us to identify themes that provide a better understanding of the breadth of this library's spectrum and the lines along which it extends.

A first observation from studying the contents of the library is that it is not a library specialized in geometry. Indeed, geometry accounts for 121 volumes (13.8 % of the corpus) whose titles use the words geometry or geometrical, surfaces, curves or curvilinear

[28] https://sorbonne-universite.primo.exlibrisgroup.com
[29] https://www.sudoc.abes.fr
[30] https://catalogue.bnf.fr

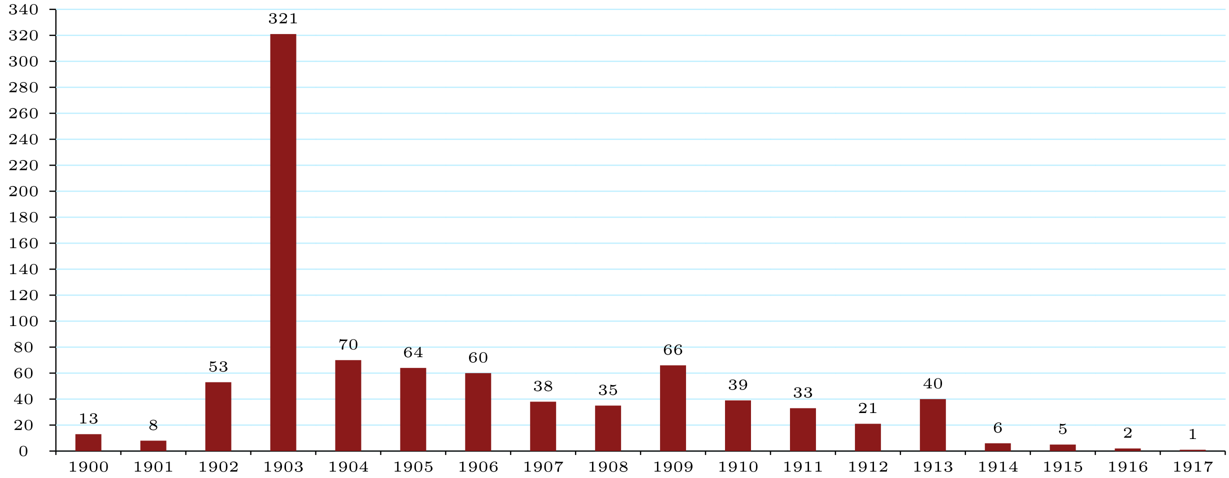

Fig. 2. Corrected chronology of acquired volumes.

or projective. Among these are 13 volumes, including four by Gaston Darboux entitled *Leçons sur la théorie générale des surfaces et les applications géométriques du calcul infinitésimal* (1887–1896) which focus on applying differential calculus to geometry. This suggests that the library served as a resource for Darboux's course at his Chair of Higher Geometry and for his research.

Alongside geometry, there are also 74 volumes (8.5 %) on analysis, whose titles, without mentioning geometry, contain the words analysis, function, trigonometry, series, differential and/or integral calculus, differential or partial differential or integral equations, calculus of variations. The place given to differential geometry and Darboux's interest in analysis (Croizat, 2016), likely explain why these themes are more represented than algebra. In this latter field, the corpus includes 17 volumes (1.9 %) whose titles mention algebra, groups, algebraic equation solving, quaternions or vector calculus. Additionally, one book (not included in the analysis and algebra corpus) simultaneously mentions analysis and algebra in its title *Elementares Lehrbuch der algebraischen Analysis und der Infinitesimalrechnung* (1904) by Ernesto Cesàro (1859–1906). In addition, arithmetic is represented by 8 volumes (0.9 %) whose titles mention arithmetic or number theory. Two books (not included in the arithmetic and algebra corpuses), *Introduction à l'étude de la théorie des nombres et de l'algèbre supérieure* (1895) by Émile Borel (1871–1956) and Jules Drach (1871–1949) and *Introduction à la théorie des nombres algébriques* (1911) by Julius Sommer (1871–1943), establish a link between arithmetic and algebra in their title. Finally, 12 volumes (1.4 %) mention mathematics in their title, without any further details. The volumes uniquely identifiable with one of the following themes: geometry, analysis, algebra, arithmetic, thus form a corpus of 220 volumes (25.1 %), challenging the idea of the library as being strictly specialized in mathematics, as suggested by Pierre Gauja in his historical account (Fig. 3).

This library also made room for works at the interface with physics. We have identified 111 volumes (12.7 %) whose titles contains the word physics, mathematical physics, mechanics, kinematics, statics, dynamics, gyroscope, potential, friction, heat, light, capillarity, elasticity, acoustics, optics, electricity or electron, magnetism, light, hydrodynamics, waves or oscillation or vibration, matter or atom, relativity or quanta. It should be noted that mechanics, at least within the Paris Faculty of Sciences, lay at the

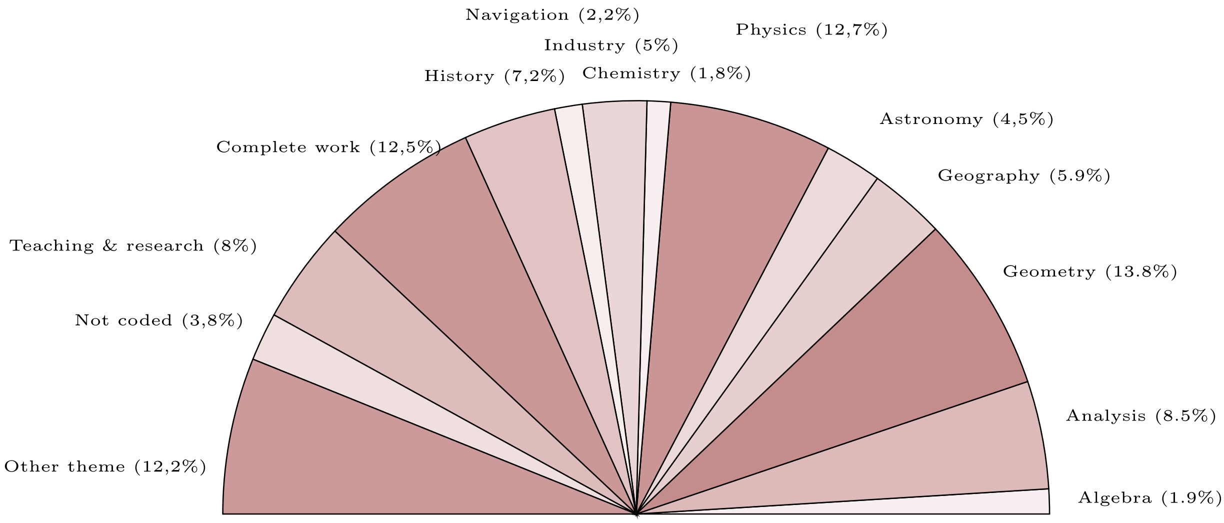

Fig. 3. Breakdown (in %) of volumes in thematic categories.

interface between mathematics and physics, with a Chair of Rational Mechanics, considered mathematical, and a Chair of Physical and Experimental Mechanics, sometimes considered mathematical or physical, and both sides being represented in the corpus. Similarly, the Chair of Mathematical Physics occupied the disciplinary interface, with a mathematical teaching of physics.

Thermodynamics is also represented in the library and forms a bridge with chemistry. We have identified a corpus of 16 volumes (1.8 %) containing the word chemistry or chemical. The four volumes of the *Traité élémentaire de mécanique chimique fondée sur la thermodynamique* (1897–1899) by Pierre Duhem (1861–1916) and the three volumes of the *Leçons de chimie physique* (1898–1900) by Dutch chemist Jacobus Henricus van't Hoff (1852–1911) highlights the connections between physics and chemistry within this library.

Astronomy is covered by 39 volumes (4.5 %) whose titles mention astronomy, a celestial body (stars, moon, sun), celestial mechanics, orbits, cosmography or cosmogony, or an astronomical instrument (telescope). Though traditionnaly considered a mathematical discipline in faculties of sciences since their inception, astronomy became increasingly independent and autonomous from mathematics, particularly between 1871 and 1914. Three other volumes simultaneously mention astronomy and geography[31]. Geography itself is represented by 52 volumes (5.9 %) whose titles include the word geodesy, topography, levelling, map or projection, surveying, geography, oceanography, or the Earth. Geography appears to be a field in which geometry is applied, with a particular emphasis on the problem of projection for map-making.

In line with the 1896 reform of the *licence ès sciences*, which aimed to broaden the scope of professional opportunities for graduates[32], this library also included a collection dedicated to industry (or technology) with 44 volumes (5.0 %) whose titles mention industry, factories, metallurgy, electrotechnics, transport (bicycles, locomotives, steam engines, automobiles, explosion engines), glass, optical instruments, photography, telegraphy, chronometry, civil engineering, or the 1900 Paris World's Fair. Notably, 5 volumes (0.6 %) link physics and industry, such as the *Cours de mécanique appliquée aux machines* (1874) by Jean-Victor Poncelet (1788–1867). In addition, a corpus of 19 volumes (2.2 %) focuses on navigation, with titles mentioning air or naval navigation, balloons, air, aviation, aeroplanes and aerostation.

Education and research also hold a significant place in this library with 70 volumes (8 %), reflecting the educational and scientific policies pursued at the end of the 19th century. Regarding education, this library covered a broad spectrum from primary to higher education. However, primary education appears as a secondary effect of the focus on secondary and higher education. We have identified 3 volumes containing reports or studies on primary education. These documents are part of collections that also deal with secondary and higher education. For example the first volume of Octave Gréard's *Éducation et instruction* (1828–1904) contains his analyses of primary education, while the second volume (in two parts) deals with secondary education and the third with higher education. We also found periodicals (not included in the corpus) on teaching and research, such as the *Bulletin administratif de l'instruction publique*.

From this perspective, secondary education received particular attention with 8 volumes (1 %). Although it is aimed at a minority of pupils, secondary education was nevertheless the primary recruitment pool for university students and the main career destination for graduates. This corpus recalls the historical role of the Faculty of Sciences in the intellectual training of secondary school science teachers, with 2 volumes on secondary school curricula. But it also places this role in a context of criticism and reform, for example with *La préparation professionnelle à l'enseignement secondaire* (1902) by Charles-Victor Langlois (1863–1929), a plea for the introduction of teacher training for secondary school teachers, but also with two volumes devoted to secondary education for women.

Higher education accounts for 36 volumes (4.1 %). Among these, 12 volumes (1.4 %) covers the history of institutions including the École polytechnique (whose centenary was being celebrated in 1894), the École normale supérieure (whose centenary, improperly, was being celebrated in 1895) as well as universities and faculties from a historical or memorial perspective. These volumes also document the transformations in French higher education, notably through the 6 volumes published by Arthur Marais de Beauchamp (1840–1895) compiling laws, decrees, circulars and regulations concerning higher education. These publications echo Darboux's functions on the *Conseil supérieur de l'Instruction publique* and as Dean of Paris Faculty of Sciences.

The attention given to the history of the Academy of sciences and the Observatory of Paris also echoes Darboux's other activities. In particular, as Perpetual Secretary, Darboux was in charge of delivering eulogies for academicians (Saint-Martin, 2012). This activity within the Academy of Sciences no doubt explains the 63 volumes (7.2 %) devoted to the history of science.

4.4. An international library with a German bias

The place given to literature on teaching and research incidentally highlights the prevalence of attention to Germany[33]. Four volumes were published in Germany, including two dedicated to the teaching of mathematics and/or physics in secondary schools. Two books published in France also deal with German secondary education: *L'enseignement des sciences mathématiques et physiques dans l'enseignement secondaire en Allemagne* (1904) by Francisque Marotte (1873–1945)[34] and *L'enseignement secondaire en Allemagne* (1900) by Auguste Pinloche (1856–1934). Thus, when it comes to education, the library offered both a German and a French vision of German education, and no other country benefited from such a treatment.

[31] It should be noted that the presence of astronomy and geodesy may partly explain the presence of 15 volumes of tables or dealing with numerical or mechanical calculation.

[32] See the report presented by G. Darboux to the *Conseil supérieur de l'Instruction publique*, (Générès, 1898, p. 559–561).

[33] From a cultural and intellectual history perspective, see Digeon (1992), in the academic field see (Charle, 1994, p. 21–59).

[34] This is a lecture given at the Musée pédagogique in 1904.

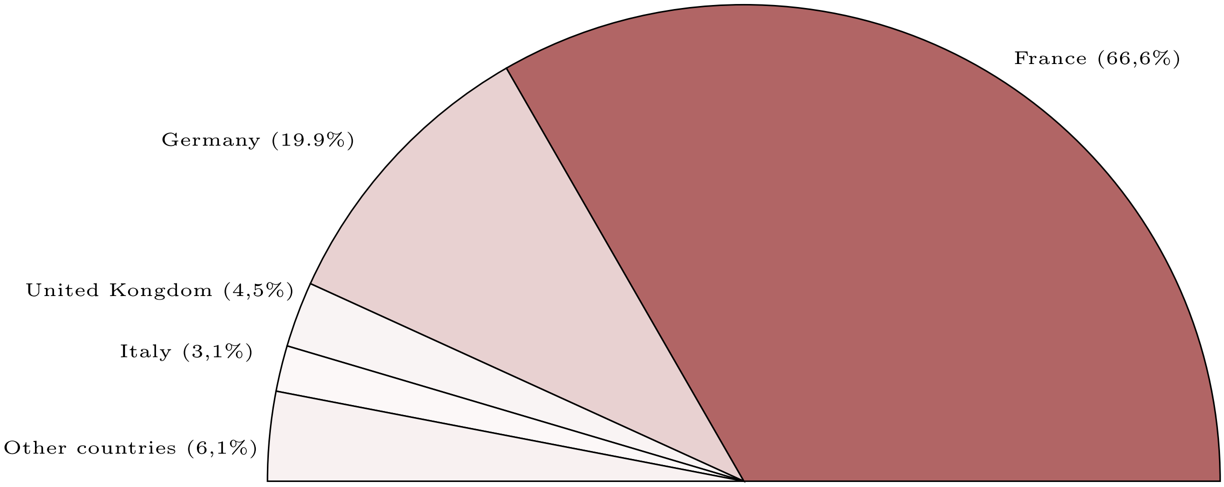

Fig. 4. Distribution by country of publication (in %) of the 875 volumes in the corpus.

	algebra	analysis	geometry	arithmetic	geography	astronomy	physics	chemistry	industry	navigation	history	complete works	T&R	Total
Germany	4	13	36	4	20		24		1		16	27	4	173
France	9	50	53	3	24	37	81	16	43	19	38	53	64	584
Italy	1	1	16		3		2				1	2		27
UK	1	4	8		2		3				5	8	2	39
Total	17	74	121	8	52	39	111	16	44	19	63	109	70	875

Fig. 5. Distribution by country of publication of the volumes in the corpus by theme.

More generally, within the 875 volumes in the corpus, Germany represents the second-largest publishing country (174 volumes, or 19.9 % of the corpus) following France (583 volumes, or two-thirds of the corpus), ahead of the UK (39 volumes, 4.5 %) and Italy (27 volumes, 3.1 %) (Fig. 4). No other country had more than ten published titles[35]. The presence of Germany in this library is closely linked to the importance of the German language, with at least 7 volumes of German-French dictionaries (not included in the corpus) and at least one German dictionary[36]. By way of comparison, we have identified at least 8 volumes of French dictionaries (including 6 volumes of the *Larousse illustré*). There's even a method for learning German, *Cent pages d'allemand pratique* (1904) by Albert Michel (1867–1939). Furthermore, only 7 volumes are French translations of German texts (i.e. 3.8 % of the volumes originally published in German). The corpus of volumes published in Germany thus highlights the importance given to literature published in this country and in its original version. The cases of English and Italian are less significant, since these corpuses are much smaller; nonetheless, the English corpus (which also includes some US publications) suggests a potential difficulty in mastering this language, with 45 volumes in the original languages and 16 volumes in French translation (i.e. 26 % of the volumes whose original language is English).

The importance attached to German publications is also evident in the diversity of themes in which they appear (Fig. 5). Amoung the 13 previously mentioned themes, German publications can be found in 10 of them. When German publications appear in a theme, the number of volumes ranges between 13 and 27 (analysis, geography, physics, history, works of art, etc.)[37] or is considerably smaller, with 1 volume (industry) or 4 volumes (algebra, arithmetic, teaching and research), and thus follows the contours of the number of thematic titles. In the case of the United Kingdom, identified in 8 themes, volumes generally range from 1 to 5 (algebra, analysis, geography, physics, history, teaching and research)[38]. For Italy, identified in 7 themes, between 1 and 3 volumes (algebra, analysis, arithmetic, physics, history and works). For both theses countries, publications in geometry are relatively high: 16 volumes published in Italy and 8 volumes in the UK. So, while the presence of the UK and Italy spans a relatively broad range of themes and is similar in proportion, the presence of Germany is generally more pronounced and relatively uniform.

[35] The Netherlands published 14 volumes, including 12 volumes of the complete works of Christiaan Huygens, counted as a single title.

[36] In the absence of precise bibliographical indications and systematic information on the number of volumes concerning dictionaries, it was not possible to count them. They were therefore not included in the corpus.

[37] Once again, the number of volumes in the Complete works ("Euvres complètes") category is also misleading, as the same title is often published in several volumes. For example, the 27 volumes of works published in Germany correspond to 10 titles.

[38] Note that 8 volumes appear in the complete works category but actually correspond to 4 titles. See note 37.

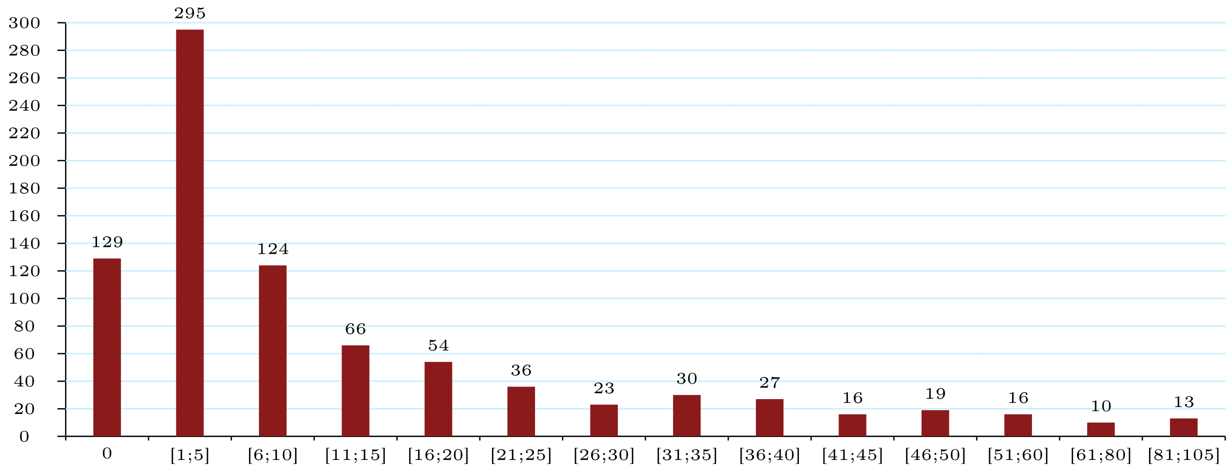

Fig. 6. Age distribution (in years) of volumes entered in the inventory.

From a geographical perspective, it is also worth noting that not all themes were treated in the same way: some seem to fall within a national framework while others open up to an international perspective. On the one hand, the themes of navigation and chemistry only include volumes published in France. For industry, only one volume is published outside France (in Germany), which tends to give a rather national vision of this theme. On the other hand, geometry appears to be the most internationalized theme, with volumes published in 10 countries: France (53 volumes), Germany (36), Italy (16), UK (8), Argentina (2), Spain (2), Belgium (1), USA (1), Netherlands (1) and Switzerland (1). Between these two extremes, most themes benefit from relatively broad geographical coverage: 7 countries for complete works[39], analysis, geography and history; 6 countries for algebra; 5 countries for physics.

4.5. A contemporary work tool forged by Darboux

Geometry stands out from the other corpuses in terms of the number of volumes and its broader internationalization which is closely linked to the Chair of Higher Geometry and the interests of its professor, Gaston Darboux. This professor's role in the shaping of this corpus is even more evident through the donations he made: 435 volumes (49.7 %). The other main supplier is the bookseller-publisher Hermann, from whom 382 volumes (43.7 %) were purchased. These two suppliers contributed in a very similar manner to all the areas selected, across all the chronological strata of publishing, and at the same rate of acquisition. These similarities underline a continuity between the acquisition logics in Darboux's personal library and purchases from the bookseller Hermann. The analysis of the 875 volumes of the corpus thus indirectly reveals that Darboux implemented a concept of laboratory libraries, on the initiative of a professor who selected its contents.

As a working tool, this library brought together recent and contemporary documents. The library's up-to-date status can be measured by the age of the book at the time of acquisition (the difference between the year of acquisition and the year of publication). While the titles of the volumes in the corpus are known, the volume numbers within a collection are not always: the edition number is sometimes unknown, or the date of publication is not provided by the Bibliothèque nationale de France (Catalogue général). In these circumstances, we have identified the date of publication (and therefore the age) of 858 volumes.

Most of these 858 volumes were published in the quarter century preceding their entry into the inventory (Fig. 6). We have identified 129 volumes (15.0 %) that were included in the inventory in the same year they were published, 423 volumes (49.4 %) published in the previous 5 years, and 704 volumes (82.0 %) published in the previous 25 years. The contemporaneity of this corpus is perceptible in all the identified mathematical fields. The 8 volumes on arithmetic were published during the previous 27 years, 6 (75 %) of which within the previous decade. The 17 volumes on algebra were published within the 16 years preceding their entry except for the two that were published 33 years before their entry. The 74 volumes on analysis were published in the previous four decades with 63 (85.1 %) published within the previous 19 years.

As an example of the attention given by Darboux to current mathematical developments, in the field of analysis, we would like to mention the place given to the new generation of French analysts and former students from the ENS: Émile Borel (1871–1956), René Baire (1874–1932) and Henri Lebesgue (1875–1941). The presence of their publications is certainly part of Darboux's promotion of these former students of the rue d'Ulm in the mathematical field, a practice that Borel would continue during the inter-war period. However these books also proposed a new direction for analysis in France. The first ten volumes of the *Collection de monographies de la théorie des fonctions*, edited by Borel, were purchased in 1906 and included as a batch in the inventory (with consecutive inventory numbers). This collection (Ehrhardt, 2011) designed to be both accessible to students (short, inexpensive books) and in close connection with current research, established a link between teaching and research. It promoted a modern theory of functions,

[39] Note that 5 volumes of François Arago's complete works are co-published in France and Germany.

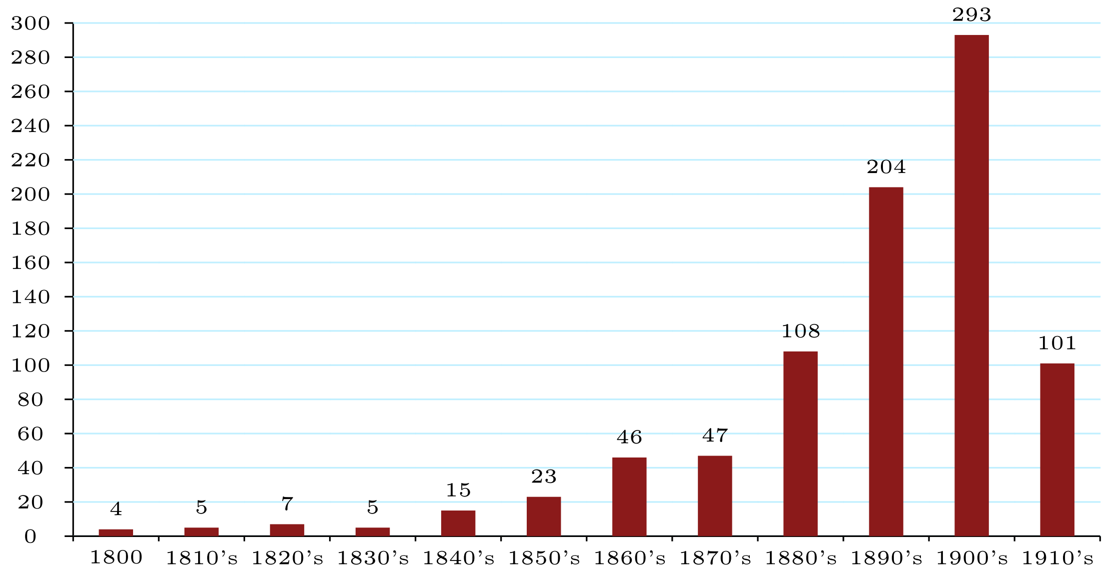

Fig. 7. Decades of editions of dated volumes in the corpus.

broadening the scope of objects and methods of analysis by the use of set theory and thus renewing French research prospects (Gispert, 1995). Furthermore, Borel, a former student of Darboux, was also close to this professor's family (Croizat, 2016, p. 49), which suggests that Darboux was also attentive to his mathematical entourage when choosing the contents of this library.

Once again, geometry stands out, as the library demonstrates a particular attention to both contemporary developments and long-term historical perspectives in this field. Amoung the 121 volumes identified, 63 (52.1 %) were published within the 5 years preceding their entry into the inventory, while 98 (81 %) were published within the previous 25 years. The remaining 23 volumes (19 %) were published between 26 and 105 years before their inclusion in the inventory. The oldest book is *Géométrie de position* (1803) by Lazare Carnot (1753–1823), added in 1908. Other old notable books are Gaspard Monge's (1746–1818) *Application de l'analyse à la géométrie* (1809) added in 1904, Charles Dupin's (1784–1873) *Développements de géométrie* (1813) added in 1904 and Jean-Victor Poncelet's (1788–1867) *Traité des propriétés projectives des figures* (1822) added in 1903.

Thus the library contained volumes published mainly between 1870 and 1916 (Fig. 7). Of the 858 volumes for which we know the year of publication, 446 (52.0 %) were published between 1898 and 1916, 650 (75.8 %) between 1887 and 1916, and 753 (87.8 %) between 1870 and 1916. The three decades 1880 (108 volumes, 12.6 %), 1890 (204 volumes, 23.8 %) and 1900 (293, 34.1 %) alone account for 605 volumes (70.5 %). This library thus stands as a snapshot, captured by Darboux, of the mathematics of his time.

4.6. The initial conditions for the heritage preservation of this library (1917)

Relatively old acquisitions play a noticeable role (40 volumes, that is 4.7 %, published at least 50 years before entering the inventory) but limited to the 19th century. From this point of view, the patrimonial character of the library does not appear to be the main driving force behind acquisitions. Nevertheless, the heritage dimension is perceptible in the acquisition of 109 volumes of complete or selected works by 18th and 19th century authors. These complete works also include those of mathematicians contemporary to Darboux, such as the works of Eugenio Beltrami (1835–1900) and the first volume of the *Euvres* of Henri Poincaré (1854–1912). Without minimizing the value of these documents for research work, their symbolic value remains strong, particularly in their heritage dimension. In this respect, the presence of an English translation of Books 3 and 4 of Euclid's *Elements* by Henry Martyn Taylor (1842–1927), published in 1891, is worth noting.

However, it was only through a process of transmission to subsequent generations that this library could truly become a heritage. By associating a library with the Chair of Higher Geometry, Darboux took the first step towards an automatic transmission to his successor, but left the future of the library to the latter's goodwill. However, following Darboux's death and the creation of the Department of Mathematical Sciences in 1917, this process took on a new dimension. On May 3, 1918, Paul Appell wrote to the *Recteur* to inform him of a decision taken by the Council of the Faculty of Sciences:

> The cabinet formerly occupied at the Sorbonne by the deceased Gaston Darboux includes various work rooms in which my eminent and regretted predecessor had built up collections of models and mathematical publications of rare interest.
>
> The Faculty Council decided that such a valuable work tool could not remain at the sole disposal of the Higher Geometry course, and assigned it to the entire Department of Mathematical Sciences.
>
> [...]

> At my request and under my direction, Mr. Pierre Gauja, *ingénieur des arts et manufactures* and secretary-editor of the Academy of sciences, is in charge of the operations of the cabinet: incoming and outgoing of books and models, maintenance, etc. (AN, AJ/16/5123, séance du 10 janvier 1918, p. 240–241)

Dean Appell thus gave decisive impetus to the transmission process, now associated with the Department of Mathematical Sciences and no longer with a single professor. He also appointed a staff dedicated to acquisition and preservation. While Gauja's work was carried out under the direction of a senior mathematician, the process became part of a mathematical collective and partly independent of the personalities of the Department of Mathematical Sciences. In this way, a library conceived by Darboux and recognized for its value by his successors could be passed on in the long term, a process whose traces can still be seen today : 689 volume titles (78.7 %) correspond to copies still present in the IHP catalog.

5. Conclusion

The creation of a mathematics library within the Paris Faculty of Sciences by Gaston Darboux appears first and foremost as the result of profound transformations in this faculty and its mathematical activity. These transformations changed the institutional structure and function of the Faculty of Sciences, encouraging personal initiative, local specialization of teaching and the affirmation of scientific research as a core mission for all the faculties. These institutional transformations materialized in buildings constructed over the last two decades of the 19th century. As Dean of the Paris Faculty of Sciences, Darboux had a front-row seat to measure the limited material resources available for mathematical research at his faculty. Moved into new buildings, and encouraged by the administration, Darboux took the initiative to create a cabinet that gathered a collection of mathematical models and a library in dedicated spaces. This library was conceived as a working tool for research and higher education shaped by a professor. Thus, the establishment of a library emerged as a response to the new demands of university scientific activity.

Far from being a library "specialized in pure mathematics" as Pierre Gauja stated in his history of the IHP library, it actually brought together documents covering a wide range of scientific, industrial and institutional topics. This spectrum reflected the desire for openness in terms of study opportunities at the Faculty of Sciences. The library also bore witness to the transformations that were taking place in education, from primary to higher education, and in research, transformations in which Gaston Darboux was one of the key players, both as dean and as a member of the *Conseil Supérieur de l'Instruction Publique*. Finally, while geometry held a singular place (being more voluminous, internationalized and gathering documents from the beginning of the 19th century) the library, by covering a wide range of relatively international mathematical news, was a common working tool for all mathematicians at the faculty.

The establishment of this library within the Paris Faculty of Sciences signified the initial phase in a process of patrimonialization. First associated with the cabinet, and subsequently, in 1918, with the Department of Mathematical Sciences, the collection of books and periodicals, recognized for its quality, could be passed on to successive generations in a process serving a mathematical collective. Nonetheless, the patrimonialization process necessitates a conservation policy in conjonction with an acquisition policy, with the objective of patrimonializing all or part of the collection of books and periodicals. Beyond the losses in the collection that have been mentioned, it remains to identify these policies and analyze their long-term effects.

Data availability

No data was used for the research described in the article.

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