Carlo Manfredi *Editor*

Addressing the Climate in Modern Age's Construction History

Between Architecture and Building Services Engineering

Springer

Addressing the Climate in Modern Age's Construction History

Carlo Manfredi
Editor

Addressing the Climate in Modern Age's Construction History

Between Architecture and Building Services Engineering

Springer

Editor
Carlo Manfredi
Politecnico di Milano
Milan, Italy

ISBN 978-3-030-04464-0 ISBN 978-3-030-04465-7 (eBook)
https://doi.org/10.1007/978-3-030-04465-7

Library of Congress Control Number: 2018965442

This Springer imprint is published by the registered company Springer Nature Switzerland AG
The registered company address is: Gewerbestrasse 11, 6330 Cham, Switzerland

Contents

Camillo Boito and the School Buildings Indoor Climate in the Unified Italy (1870–1890)

Alberto Grimoldi and Angelo Giuseppe Landi

Abstract Compulsory schooling in some Italian States, especially in the Duchy of Milan, dated back to the end of the eighteenth century. Following the legislative proposal submitted by Minister Michele Coppino, compulsory schooling in the whole new kingdom of Italy initiated instead only around 1877, over 16 years later than the unification. Even if the Italian State funding were low, they nevertheless encouraged the construction of new school buildings and imposed new standards. Italian architects showed a great interest in the topic and develop new solutions, sometimes inspired by current European experimentations and publications. Architect Camillo Boito built two schools, both in Padua (1877–80) and Milan (1886–1890), which represented a concrete example of his idea of a new and "national" architecture. Up-to-date construction techniques were developed and thermal comfort was also improved, according to the standards of that period. The centralized heating systems adopted in the two school buildings testified to the fast development of industry, particularly in Milan, which become the most important Italian center in the sector.

1 Introduction. From Mandatory Schooling to School Buildings; from the Age of Enlightenment to the Belle Époque[1]

Compulsory education grew up slowly in nineteenth-century Europe, creating new issues of great significance, including of a quantitative nature, to the sector of public building, the schools themselves in its various types.

[1]This research develops and completes a lecture held at the 9th International Conference on Structural Analysis of Historical Constructions (Mexico City, 14–17 October 2014). This paper is the outcome of a common research by Alberto Grimoldi (about the biographical aspects) and Angelo Giuseppe Landi (institutional aspects, buildings and case studies).

A. Grimoldi (✉) · A. G. Landi
DAStU—Department of Architecture and Urban Studies, Politecnico di Milano, Milan, Italy
e-mail: alberto.grimoldi@polimi.it

C. Manfredi (ed.), *Addressing the Climate in Modern Age's Construction History*,
https://doi.org/10.1007/978-3-030-04465-7_5

In terms of quantity, rural schools were certainly at the heart of the problem; indeed, in the small towns and in the cities of Catholic countries, after the abolition of religious orders and brotherhoods, the ample spaces of monasteries and the halls of the confraternities could be assigned to the education. France had precociously decreed compulsory and free primary education in 1793, only to quickly abandon it. In the Habsburg States, as early as the final years of the reign of Joseph II (in Milan in 1788), the matter proceeded with great difficulty yet did not founder: a kind of construction manual, Koller's *Der Praktische Baubeamter*, presented not only models for rural schools but also a regulatory framework (Koller 1800).[2]

Certain characteristics relating to health were already emerging: lighting of desks had to be from left to right. With the advance of industrialisation, school buildings as a building type, in terms of their overall function and educational impact, as a design topic, took on particular importance. The regional imbalances increased with the industrial take-off, and combined with the population increase; re-use of existing buildings no longer sufficed and, with new buildings now considered indispensable, specific standards were progressively defined (Fig. 1).

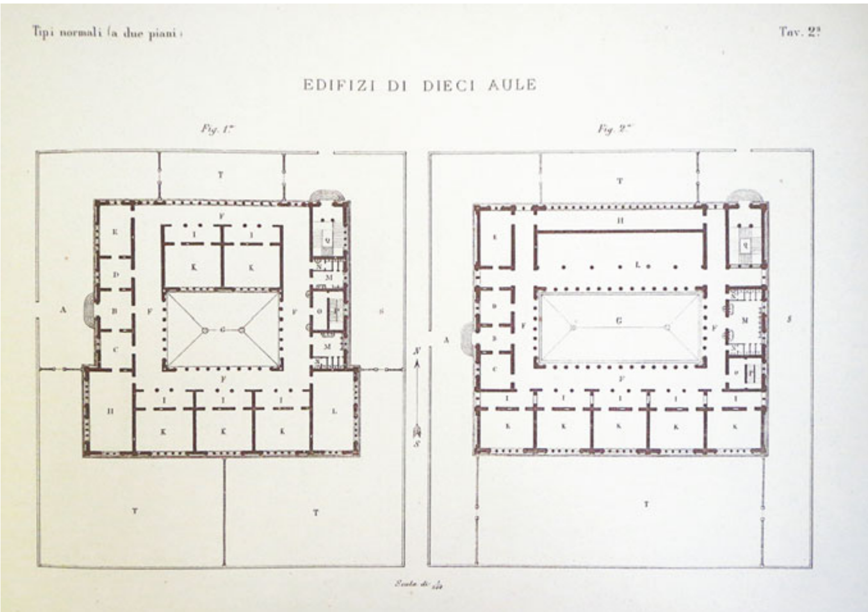

Fig. 1 School of ten classrooms ("Edifizi di dieci aule, planimetrie"), Bongioannini (1879), tav. 2

[2]pp. 39–41, figg. LXXVI–LXXVIII; II part, pp. 410, 458–461.

From 1851, the World Fairs, whose purposes included education, dedicated specific spaces to school buildings. Legislation reinforced public schooling and, after a century of attempts, mandatory primary education began to be effectively translated into practice and its duration was increased to three years. The education laws of the German States, that of the Habsburg Empire of 1869, the Education Act of 1870 in England and 1872 in Scotland and the laws of 1877 in Italy and 1882 in France boosted significant building activity and gave rise to regulations governing it. Specific bibliography on school building health grew notably, and crossed citations became numerous.

An overview of the history of Italian school building was still lacking, while literature on schools as an institution and on teaching was extensive although uneven. However, the previously-mentioned bibliography at European level, together with certain fortuitous circumstances, permitted, between the Italian Unification and the end of the nineteenth century, an overall vision of one particular aspect: climate control within schools. In this sense, the general concept of the buildings was still more determining. Subsequently, after the first world war, ventilation would become a secondary exigence in reference to the new medical guidelines, and the industrial take-off and diffusion of electric motors would reduce the bulk of installations, entrusting ambient balance to them.

2 School Legislation in Italy After the Unification and the Birth of Regulations on School Buildings

The Casati Law (1859) required municipalities to institute and finance the first two years of primary education in all areas where there were at least fifty children, but subordinated this to the requirements of the population, as determined by the municipal councils. In 1877, Education Minister Michele Coppino reduced compliance to one school per municipality, but made it possible for the Government to substitute for the defaulting municipalities at their expense. In return, he provided meagre financial support; indeed, Law no. 4460 of 18/07/1878 granted municipalities the faculty to contract loans of up to thirty years with the Italian Deposits and Loans Fund—in part with interest limited to 2%, thanks to the State's contribution—for building or repair of school buildings. This Law limited the interest burden on the Italian Ministry of Public Education to 50,000 lire per year. This assistance consisted, more than anything, of the offer of sufficiently ample long-term funding at a reduced cost (De Fort 1979),[3] but had limited results (Fig. 2).

The implementing regulation[4] defined the first brief guidelines on building choices. The substantial reiteration of these contributions at the end of the decade[5]

[3]pp. 185–186.

[4]Regio Decreto no. 4684, 13/12/1878 (Gazzetta Ufficiale 24/2/1879, no. 45).

[5]Law no. 5616, 8/7/1888 (Gazzetta Ufficiale 16/7/1888, no. 167).

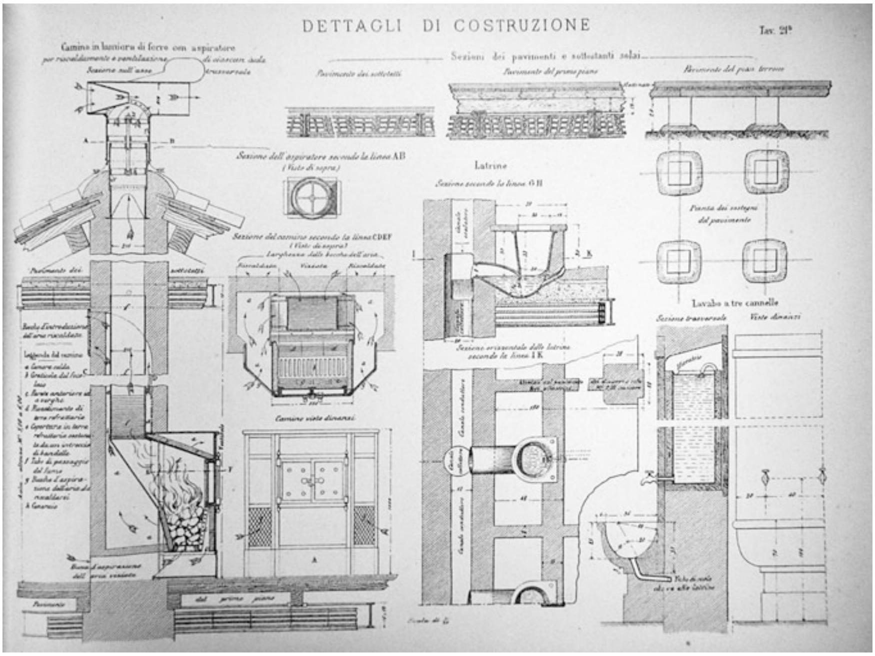

Fig. 2 Construction details, including the heating system ("Dettagli di costruzione"), Bongioannini (1879), tav. 21

was accompanied by more detailed instructions.[6] The new century began with a further reiteration,[7] together with new regulations. This sequence of events shaped increasingly detailed regulations on school buildings,[8] the three pages and 13 articles of 1888 became five pages and 18 articles in 1901. The relationship of these with buildings, constructed or merely designed and published, was two-fold. The "instructions" adopted the introduction of certain advanced solutions which had emerged during the previous decade, and their enactment was also notable in parallel changes to some standard dimensions or solutions. Overall, rapid technical progress was perceivable together with a change in expectations and attitudes.

For instance, in 1888, the required artificial lighting consisted of lamps situated at least 1.5 m from the students' heads. Where electric lighting is not used, oil, petroleum or gas burners should be chosen. Where gas lighting was adopted, the application of combustion product waste pipes was recommended. In 1901, an entire article recommended the use of incandescent electric lighting. If it was

[6]Regio Decreto no. 5808, 11/11/1888 (Gazzetta Ufficiale 30/11/1888, no. 282), "Regolamento ed istruzioni tecnico-igieniche per l'esecuzione della legge 8 luglio 1888 sugli edifici scolastici".

[7]Law no. 260, 15/7/1900, (Gazzetta Ufficiale 21/7/1900, no. 169).

[8]Regio Decreto no. 484, 25/11/1900 (Gazzetta Ufficiale 10/1/1901, no. 8).

necessary to resort to gaslight, each lamp should be fitted with incandescent mantles. Electric lighting quickly spread in the major cities, where the demand for new schools was highest, while energy transmission made it increasingly widespread. Gas lighting, dependent on supply networks, was used in a limited number of urban centres and, in 1901, only its most advanced and low-consumption form—the Auer von Welsbach gas mantle, patented in 1876—merited the regulation drafter's attention.

However, rural schools kept using oil (or petroleum) lamps with glass flues ("waste pipes"), despite the alternative of "combustible gas" (namely acetylene) proposed by the regulation of 1901.

3 The Museum of Teaching and Education

In reality, as would occur the following year with regard to financing, Coppino rationalised or developed earlier initiatives and brought them to fruition. These were the projects of former Education Ministers Cesare Correnti (1872) and Antonio Scialoja (1873). The need for improvement in the quality of education was generally felt and Ruggiero Bonghi,[9] Minister of Public Education from September 1874 to 1876, founded the Museum of Teaching and Education[10] in 1874 with this objective. Following a trend that was spreading throughout Europe (Tauro 1903[11]; Cossetto 1997), this Museum gathered information and educational materials, from books to wide-ranging objects, in the service of that teaching by means of things, "objective lessons", models or samples, that distinguished the nineteenth-century education. The Museum aimed to become a reference point for the schools of the Kingdom of Italy, and for this objective published its own journal (Sanzo 2017[12]). Bonghi announced the programme in his report on the Vienna World Fair in 1873 (Bonghi 1873[13]), and the same book featured a report on architecture by the architect Camillo Boito (Boito 1873[14]). School buildings, naturally, formed a—limited but essential—part of this programme.

[9]From 1866 to 1874 he was editor of the Milanese daily newspaper *La Perseveranza*, which published some essays of the architect Camillo Boito [from 1860 to 1865, according to the list of his publications in s.a., Boito (1916, pp. 176–205)].

[10]Regio Decreto 15/11/1874 no. 2212, published by Tauro (1903, pp. 9–10). The most relevant documents on the foundation and the live of the Museum life are collected by Sanzo (2012b). Concerning the object of this paper, a nearly contemporary and already mentioned witness, Giacomo Tauro and his work, is very useful. For a more overall perspective Sanzo (2012a) and also Meda (2010).

[11]pp. 3–5.

[12]pp. 99–120, antecedent bibliography pp. 116–119.

[13]pp. 33–34.

[14]pp. 17–29.

Through a Ministerial Decree of 30/12/1875, Bonghi established the commissions that would oversee the Museum's activities, including the one for school building design, composed of a doctor (Angelo Scarenzio), an agronomist (Fausto Sestini) and two engineer/architects (Francesco Bongioannini and Giulio de Angelis). The latter is very well-known, being among Rome's most original late nineteenth-century architects and, at that time, he had just designed a villa in Rome for the Minister Bonghi (Zullo 2005[15]); after a successful professional career, he returned to public employment in 1895, as Director of Lazio's Monuments Department (Zullo 2005[16]; Miano 1987).

4 Francesco Bongioannini

The former had been an inspection engineer at the *Soprintendenza archeologica* of Rome from 1872 (La Rosa 2011[17]; Scavi 1872[18]) and, when this was closed, in 1875, he entered the newly-established *Direzione Centrale per gli Scavi e i Musei* (Melis Tosatti 2005[19]) in the capacity of topographical engineer; the following year (La Rosa 2011[20]) he became General Inspector for Architecture, preferred to Giulio de Angelis.

In this way, he moved into the "Divisione 2a" which, from 1877, assumed the name *Provveditorato alle Arti* of the Ministry of Public Education, directed by Giulio Rezasco (La Rosa 2011[21]). When the *Provveditorato* and the *Direzione Centrale per gli Scavi e i Musei* were merged by the Minister Guido Baccelli, in 1881, Bongioannini continued his work and, when in 1887 the direction was structured in three sections he assumed directorship of the "Divisione II", with responsibility for conservation of monuments (Melis Tosatti 1999[22]). After the restructuring ordered by Minister Pasquale Villari, in 1891, Guido Baccelli, returning as Minister in 1895, partially re-established the *status quo* but Bongioannini returned to Turin as superintendent of schools (L'osservatore scolastico 1896[23]), and, at the end of his career, was transferred to Alessandria, in the Piedmont region (I diritti della Scuola 1908[24]). He can again devote himself to the school buildings (Bongioannini 1898).

Bongioannini's role at the Ministry of Public Education made him the immediate administrative reference person for Camillo Boito, a member of the *Giunta*

[15] pp. 38–39.
[16] pp. 144–190.
[17] p. 25.
[18] p. 34, no. 47.
[19] pp. 186–87.
[20] p. 27.
[21] p. 31.
[22] p. 190.
[23] p. 12 (nomination: 26/8/1896).
[24] p. 531.

Superiore di Belle Arti since 1879. This relationship may be deduced from the murky and inglorious affair of the destruction of the Church of San Giovanni in Conca, in Milan, an obstacle to the straight stretch of the new via Carlo Alberto, in which the two cooperated to promote the City Council's demolition intentions (Colombo 2005[25]).

This singularly close relationship between the debate on school buildings and the care of monuments is of little wonder: both competences were centralised in a single ministry, often managed with equal interest by a single minister, pointing more to a network of personal relationships than to a continuity and sharing of concepts.

Bongioannini's texts place greater emphasis on the topics of education, although their titles are, at times, deceptive. The multiplicity—to the point of confusion—of his interests and their interweaving with his administrative activity are typical of that century, thanks to a population curve that quickly led to positions of responsibility. Fluctuation between utopia and mania and between egocentricity and social commitment are characteristic of the nineteenth century, meaning that both actions and texts should only be assessed with close reference to their context, taking no account of the different meanings that words and phrases may subsequently have assumed later. Another great and polyhedric bureaucrat of that era, Carlo Alberto Pisani Dossi (Melis 1996[26]; Serra 1987), depicted this environment and these tendencies—linking society and architecture—in a famous pamphlet dedicated to the "madmen" in the competition for design of the national monument to Vittorio Emanuele II in Rome, called "Vittoriano" (Pisani Dossi 1884). The tone he adopted—exasperatedly grotesque—highlights the tendencies and characteristics of an era, which permeated its daily life but in that dimension they appear attenuated as with inactivated vaccines.

Bongioannini dedicated his engineering degree thesis to heating (Bongioannini 1870), another key theme in the problems discussed here, and initially he planned to base his professional identity on these issues. The habit, that time, of the *Scuola di applicazione per gli Ingegneri* in Turin, of presenting degree theses as printed pamphlets made his brief essay easily accessible. In Rome, the Piedmontese origin—or the exile to Turin between 1848 and 1859—of a significant portion of the higher bureaucratic levels, provided the young engineer with a promising network of relationships, and his sufficiently generalist technical expertise permitted him to meet a varied demand. He was able to achieve the drainage of waters in the Roman Forum, in order to resume excavations (Scavi 1872), but also to design the layout for the arrangement of the *Collegio Romano* as Roman seat of the National Library, one of Ruggiero Bonghi's priorities. Like de Angelis with Bonghi, he designed the Roman residence of Minister Michele Coppino, in 1886: a five-storey rental house at via Cavour no. 194 (La Rosa 2011[27]). The abstract regularity of the fascias and stringcourses, which show the identical height of the internal spaces, allude to an

[25]Overall pp. 96–97.

[26]pp. 169–170.

[27]pp. 51–52 and 68.

only partially-existing structure. Any revival or adaptation of Renaissance themes to new proportions and requirements, so widespread in the Rome of his day, is distant, and this anomaly also attracted Paolo Portoghesi, now sixty years ago (Portoghesi s.d.[28]). While unable to establish its paternity, he connected it to a limited but significant group of buildings which could refer to similar cultural roots. The search for an unconventional “new style”, from a “rationalist” perspective, as a pure construction, was not rare in the Piedmont region, particularly for explicitly utilitarian programmes.

At the *Scuola di Applicazione per gli Ingegneri* in Turin, when Bongioannini was a student and showed especial interest in industrial engineering, the professor in architecture was Carlo Promis (Savorra 2017), who also held the equivalent chair at the city’s Accademia. He was substituted for just one year (1870) by count Carlo Ceppi, and then he leaved the post to Giovanni Castellazzi (Richelmy 1872; Pugno 1959; Vitulo 1993[29]), who proclaimed himself a student of Promis’. Also decisive in the field of construction, particularly in road- and railway-building, was the influence of Giovanni Curioni, teacher in different positions, from 1863, and repeatedly indicated as the effective Department Head.

5 A Model for Municipalities

In his illustrated book on schools (Bongioannini 1879) Bongioannini adopted the same architectural language. The activities of the Museum of Teaching and Education included annual conferences and, during those of 1876 and 1878, the first issue “school desks and houses” was presented respectively by Girolamo Buonazia, professor of Applied Mathematics at Florence’s *Istituto Tecnico* and *Accademia di Belle Arti*, and by Antonio Labriola, the Museum’s own Director (Tauro 1903[30]). The Secretary General, Martino Speciale, a lawyer and long-time member of Parliament—called upon to ensure the continuity of a ministry in which, due to the frequent government crises, Francesco Paolo Perez and De Santis succeeded Coppino—responded to the dedication to the Minister, a generic “His Excellency”: he requested to provide two hundred copies to the Ministry, so that the book “may be made known to the provincial school authorities”. He referred to an old eighteenth-century custom according to which the dedication corresponded to a purchase of copies, here pre-arranged within the same offices.

The types of buildings for primary schools (Fig. 1)—which, “through the explanation given of them last year at one of the School Museum’s Teaching Conferences … gave rise to a decision … that the Municipalities should be informed of them …”—are delineated with the help of the *quadrillage* of Durand

[28]p. 76 (and photos nn. 127–128, p. 84).
[29]p. 63.
[30]p. 13.

who, in turn, loved the regularity of Turin (Szambien 1984[31]). Another reference to the teaching of the *École Polytechnique* is the division of buildings into modular elements, in this case the classroom with the vestibule. These, in turn, may be broken down into single square modules. With their porticoes in place of corridors, which were reserved—although it is not known how—for the harshest climates, sequences of columns and over-abundant distribution, arranged according to the same modularity, these school buildings were presented as a model of "rational composition" which would also give rise to "rational constructions". Composition and construction were originated by the function, in a programme combining traditional reflections on the choice of area with the most binding quantitative, regulatory and sanitary specifications of compulsory schooling. This approach involved "seeking, in all their essence, the most important monumental buildings, attempting to understand the ideas that shaped them … repeating, on each of them, all the workings of the mind that created them" (Bongioannini 1879[32]). The principles of Viollet-le-Duc expressed the great—and contradictory—desire of that century, namely progress freely built on the nation's past and individuality. Referring to these, Bongioannini sought to provide school buildings with the necessary link to history as well as the essential didactic dimension. Rational construction aimed to emphasise the regular stone or brick load-bearing structure, clearly distinguished from "infills", like Gothic and even "Lombardesque buildings" (Bongioannini 1879[33]), a further, generic, *filius temporis* homage to the myth of the rationality of medieval construction. Of course, "the decorative parts are not achieved through superfetation but by embellishment and ornamentation of the constructional parts, while, for the classrooms, successive… openings in the form of a continuous window … are envisaged … divided only by pillars or small columns" (Bongioannini 1879[34]). The text, often confused and redundant, particularly in its historical *excursus*, conceived—it would seem—in homage to the principle "*repetita iuvant*", shows via which humble, involuntary routes, that Kaufmann would never have imagined, it is possible to slowly advance on the path "von Ledoux bis Le Corbusier". It is therefore advisable to focus on building health and trace another stage in the development of standards. The seventy student classrooms stated in the Regio Decreto no. 4684 were limited to fifty students, each of whom were entitled to a volume, corresponding to the height, of five or six metres, depending on the clemency of the climate; 13–15 mq were also added for the teacher. The air had to be renewed two or three times per hour, and the glazed surfaces—1.5 m above the ground, in order to render them inaccessible to children—had to be a minimum of 1/40 or 1/30 of the volume, i.e. 1/5–1/3 of the floor area. While uncertain and variable, standards were taking a direction. Heating was provided by a stove located in the vestibule, on the wall towards the

[31]p. 34 (footnote no. 17).
[32]p. 8.
[33]p. 34.
[34]p. 24.

classroom (Fig. 2). The fireplace was fed by "stale" air, which entered via a vent opened at the level of the classroom floor and exited as smoke via the chimney flue. Instead, fresh air entered via the grates to the sides of the stove, flowed around the stove and in a large flue within the wall thickness, surrounding the iron smoke flue, and warmed up exited in the classroom, just below the ceiling. References to use of this equipment as a summer ventilation system, activated by a flame of obviously reduced intensity, perhaps limited to a gas or acetylene burner, are unconvincing. The teacher played a key role, being able to open the window transoms and operate the external tiltable shutters ("cord shutters") or "Chinese-style shades", consisting of thin, fixed, wooden battens, and the internal blinds in order to protect preferably south-facing rooms from solar radiation. Bongioannini made little use of the notions exhibited ten years earlier; indeed, these guidelines and tools for climate control appear incoherent and, above all, vague, as though the interest of users and the ability of the municipalities to apply them were very scarce.

6 Camillo Boito and the Schools of Padua at the Reggia Carrarese

The primary school designed by Camillo Boito for the city of Padua briefly pre-empted the first two stages of the regulations about the school building. This was, perhaps, no coincidence: he succeeded in skilfully presenting his work as an example in the official spheres and broadcasting it to the public of technicians and administrators, and was able to obtain resources far superior to those granted to other architects. The documentation demonstrates that his buildings were carefully considered and, to varying extents, imitated. The reports and articles illustrating them and the publications citing them also offer a broad picture of the European literature of the subject and therefore of the references known to the technicians and educated Italian public of the period, which, indeed, were promptly reflected in constructions. In fact, they set the standards for more complex school buildings, also in terms of well-being and installations (Figs. 3, 4 and 5)

In Padua, Boito won the assignment on 6th March 1877, and the building was inaugurated at the end of September 1880 (Serena 2000; Vettori Ardinghi 2012). The Minister Coppino had presented his bill on compulsory schooling to the Chamber on 9th February (Talamo 1983), and the law was approved on 6th July of the same year. In this singular interweaving of dates, the Padua initiative would seem to suggest tangible political support for a Minister, Coppino, who was in a broader sense, man of culture, active not only in the education problems but also in the issues of monument care. He proposed a bill on the subject to the Senate on 3rd February 1877 (Nicolini and Sicoli 1978[35]). In 1888, his subsequent proposal, already approved by the Chamber, was rejected by the Senate by secret ballot (Bencivenni et al. 1992). On that occasion, again, Boito assured his support to

[35]Chronological table of parliamentary debate at pp. 64–68.

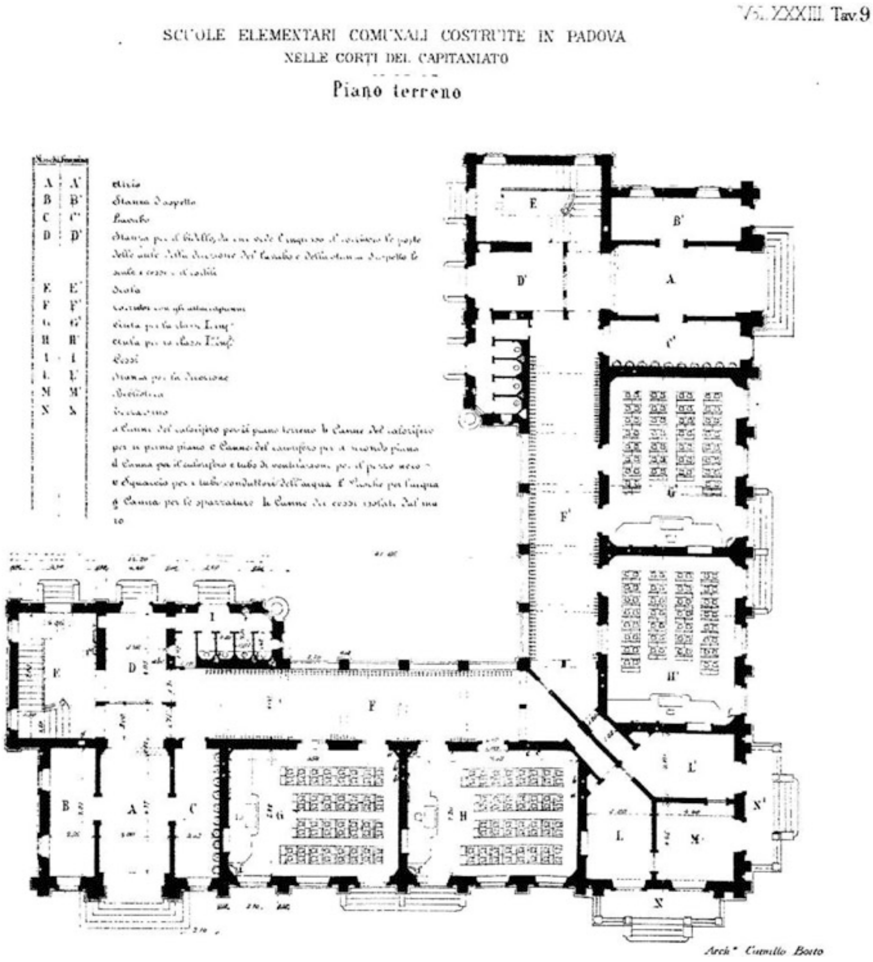

Fig. 3 Primary school at the "Reggia Carrarese" (Padua, It), groundfloor plan, Vittanovich (1885), vol. XXXIII, tav. 9

Coppino (Zucconi 1997[36]). In his report of 29th August 1877, Boito repeatedly cited the work of the Commission established by Bonghi, particularly when he claimed not to adhere to its guidelines. His building comprised three storeys, in contrast to the prescribed two, and his orientation draws the greatest possible benefit from the area, as is essential when situated within the urban fabric of an historic city. The "large, comfortable, well-lit […] 5-m-high classrooms housed less than 70 students for the first and second classes and approximately 40 for the third and fourth class. The windows were separated by "very narrow piers in order to avoid

[36]pp. 265–266, no. 58.

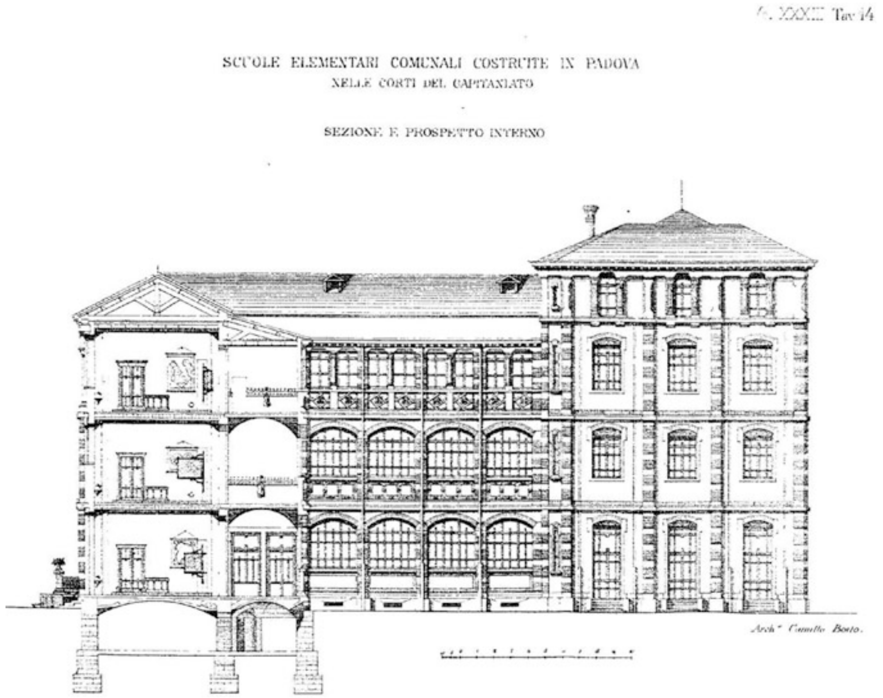

Fig. 4 Primary school at the "Reggia Carrarese" (Padua, It), cross section and internal front, Vittanovich (1885), vol. XXXIII, tav. 9

shadows", with sills 1.5 m above the ground, and their surface area was between a quarter and a fifth of that of the rooms, equal to 70 m^2. The plan for heating and ventilation was more complex: the Commission "elected by the Council", which followed the project from its origins, did not always agree with Boito's proposals. He had to renounce the vents at the base of the walls, under the windows, for "eradicating the impure air of the lower layers". The squares, clearly visible in the design drawings, disappeared in the subsequent engravings. Ventilation was provided by the window transoms, which were quadripartite in order for the panels to fold into the wall thickness. Heating, to be "artificial, even on the harshest winter days", was opposed by the Commission, for "extremely serious reasons", namely the running costs which would be borne annually by the Municipality and, consequently, by the tax-paying citizens. Hostility towards mandatory schooling itself was rife among the influential figures of the Lombardia and Veneto regions, and the gaps in the Casati Law were an advantage not secondary to National Unity… With the exclusion of individual stoves and "hot water heaters, extremely costly to install and maintain", air heaters "which do not cost much and are easy to repair" were suitable for providing 12–13 °C, but 8 °C or 9 °C would have sufficed in the new school (Fig. 8).

Fig. 5 Primary school at the "Reggia Carrarese" (Padua, It), East front (1988)

Boito succeeded, at least, in enforcing the installation of "horizontal pipes between the floor and vaults, and vertical ones in the walls". While somewhat unclear, this phrase recalls a proposal by Rinaldo Ferrini—a colleague at the Politecnico—who contemplated, for schools, the circulation of hot air under the

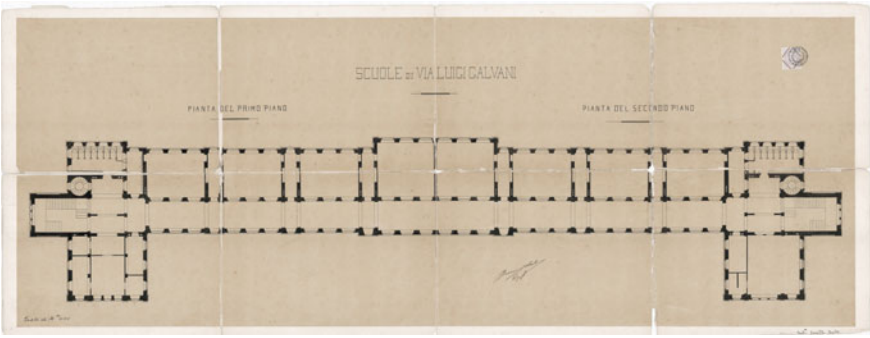

Fig. 6 Primary school in via Luigi Galvani (Milan, It), plan of the first and second floor, 1 February 1888, original scale 1:100. In: Archivio Civico Milano, Beni Comunali, Finanze, cart. 226

floor, having it rise in the front of the desks (Ferrini 1876[37]). In the end, on 29th November 1879—among the other alterations which significantly increased the estimated cost of 265,000 lire—a contract was entered into with Giuseppe Pollino for the construction and installation of two heaters at the "greatest possible reduction on the forecasted 5200 lire. The heater vent covers throughout the establishment must be made from brass". This was the most widespread solution at the time in dwellings, with vents at the base of the walls (Curioni 1873[38]; Sacchi 1874[39]). Among the drafters of the most diffuse manuals, Curioni, in particular, appears to have been a promoter of natural circulation, introducing clean air from below and removing it from above. Sacchi varied according to the circumstances, and appears to have preferred inverted circulation for very crowded environments. Ferrini also, opted for this solution: that appears contradictory. He was familiar with the work of Reid at the House of Parliament (Ferrini 1876[40]) and used the illustrations from his treatise in which natural circulation is increased using extractor chimneys (Manfredi 2013[41]). The authority of Morin and the French experience prevailed, in part due to the variety and breadth of testing of centralised systems.

At that time the standard (Ferrini 1876[42]; Sacchi 1874[43]) involved an internal temperature of 15 °C when 0 °C were detected outside. The French regulations of 1880 (Règlement 1881[44]) also set similar values (between 14 and 16 °C). The air

[37]p. 451.
[38]p. 236.
[39]p. 678.
[40]pp. 384, 441, figg. 101–104.
[41]pp. 208–209.
[42]p. 388.
[43]p. 656.
[44]p. 9.

Fig. 7 Primary school in via Luigi Galvani (Milan, It), plan of the first and second floor. Front detail on the street: the air vents viewable below the windows have been later optured. *Credits* Valisi (2014)

Fig. 8 A stove (patented by Louis Frédéric Staib) is described in the printed catalog of the Edoardo Lehmann company (1888)

flowing out of the vents should, once again according to Ferrini, range from 35 and 40 °C, at a velocity of 0.4–0.7 m/s: these were the limits typical of natural circulation. However, the temperatures actually achieved remained uncertain: Cantalupi indicated temperatures of 16–18 °C to be achieved in meeting rooms (Cantalupi 1862[45]), while the tables for dimensioning of heaters cited by Sacchi refer to temperatures of around 13 °C (Sacchi 1874[46]). The variations are probably due to the presence of people and to gas lighting.

The dimensions adopted in the Reggia Carrarese were simply repeated by Bongioannini in 1879, while, in Boito's work, they were translated into a certain architectural concept in which intentions are rendered concrete in design with the maximum coherence. This explains the success of the school in Padua, the visit from the Mayor of Venice on 6th March 1881 and the sending, in 1882, of eight photographs to the municipalities of Rome, Naples, Turin, Milan, Florence, Verona and Venice (Vettori Ardinghi 2012[47]), the Museum of Teaching and Education of Rome and the Museum of Education newly founded at the University of Palermo.

In 1885, Pietro Vittanovich, the Padua superintendent of schools, and a teacher at the local secondary school illustrated the building in the *Giornale dell'Ingegnere* (journal and organ of the *Collegio*, the Milanese Association of Engineers) reproducing word-for-word, without quoting it, the very extensive steps of Boito's handwritten report (Vittanovich 1885). The article was then re-printed as an extract, with drawings corresponding to the constructed building. It cited numerous publications from the rest of Europe and the United States. Some of the books were available in Milan, kept in the library of the Politecnico, and the majority in Rome, at the Museum established by Bonghi, responsible for gathering documentation on school buildings.

The keen interest of architects and engineers is clearly visible both in the proliferation of local pamphlets, often difficult to obtain, and in the summary—a low-cost publication—by Giovanni Sacheri: the international scene is reconstructed, above all, by the materials exhibited or illustrated at the World Fairs of Vienna (1873) and Paris (1878) which explain "exotic" references, such as Norwegian schools (Sacheri 1883).

7 The Schools of via Galvani, Milan

The importance that Boito attributed to school architecture is confirmed by his design for the 24-classroom complex of the industrial district to the north of the city, a context very different to the historic centre of Padua, yet equally

[45]p. 356.
[46]pp. 625, 627.
[47]p. 20.

high-profile.[48] The Mayor, Gaetano Negri, awarded him the assignment on 7th April 1887, and the design was delivered on 6th November of the same year. On 13th December 1887, the City Council requested a reduction on the estimated cost of 610,000 lire. On 25th January 1888, Boito presented an alteration reducing the costs to 496,000 lire, which was approved by the City Council on 4th February. The central pavilion was re-sized: the first design planned a two-storey gymnasium together with a large drawing studio on the third floor, flanked on both sides by classrooms for manual work. Only the ground-floor gym remained. On final balance, the costs rose to 583,000 lire, that is 24,000 lire per classroom. The councillor who complained of costs tripling those of other schools designed by the Technical Office was, in any case, in error. Numerous opinions underlined—in agreement with the architect's report—the value of the building as a model and, indeed, the need to further raise the standard of school premises (Figs. 6 and 7).

The classrooms, measuring 61.5 mq, were designed for 48 places. The surface area of the three windows, 1.4 m above the floor, totalling 15.3 mq, equalled a quarter of the floor plan. The wall on the corridor side was—unlike in Padua—opened up by windows corresponding to the external ones, and all of them were fitted with transoms for ventilation. Under the central windows, as many vents were created in the base of the external walls and the spine wall, measuring 1.2 × 0.2 m, then openable and now blocked but easily recognisable due to their stone cornices, to improve ventilation. Bongioannini (Bongioannini 1870), followed by Ferrini, had already recommended air intake vents at the base of the walls and warm air outlets near to the ceilings, a mixing system closer to the French studies than to the English experiences, in which ventilation air was drawn in from below and out from above, thus using natural heating. However, extraction from below was, from a physical perspective, quite different from drawing in fresh air, as occurred in this case. In the lateral walls, channels were, in any case, provided in order to activate artificial ventilation, heating the air within the ducts using a gas burner to achieve an updraft.

However, heating, closely linked to ventilation, remained uncertain. Indeed, on 24th November 1887, the Health Commission recommended low-pressure steam heating, currently being installed at the premises of another school building, the *Società di Incoraggiamento Arti e Mestieri*. A long tradition was coming to an end, and technological progress was now rendering these more complex systems reliable.

The uncertainty of the report was pure opportunism, because the decision, partly due to cost limits, had already been made and the masonry ducts are clearly visible in the design drawings, attached to the ruling of 4th February 1888. However, only upon request by Boito himself, on 13th May 1889, did the procedure for selection and assignment by direct agreement begin. Five firms—Zanna, Guzzi & Ravizza,

[48]All the documents concerning the school of via Galvani—if here are not different indications—are located in in Archivio Civico del Comune di Milano (hereinafter ACMi), Beni Comunali, Finanze, cart. 226–227.

Mussi, Lehmann, and Besana & Carloni—had submitted proposals, and a commission (consisting of architect Angelo Savoldi, Boito himself and, upon a Boito's proposal of his colleagues, Rinaldo Ferrini and Cesare Saldini) had limited the field to air ventilation and to three firms: Besana & Carloni, Guzzi&Ravizza, and Lehmann. The latter would be awarded the contract in accordance with a prefectural authorisation of 29th August.

8 The Companies' World?

The procedure followed makes it possible to reconstruct the state of the art in the sector, and—by comparison with conserved documents regarding other, similar installations—the ongoing developments. Renouncement of "maximum high-pressure" steam was due to its installation cost, correctly valued as double that of an air system, its burdensome maintenance and the need for specialist personnel to manage it.

Air heaters, particularly in Milan where an early example dates back to the mid-eighteenth century (Forni 1997), was already traditional; indeed, advanced versions were also available which heated a lot of air to a relatively reduced temperature, while the "old-fashioned" models still offered little air at high temperature. These were not new issues but, rather, reflected the literature of ten or even twenty years before. Air heaters were merely large "circulation" stoves and also offered advantages in terms of scale. As the size of a building increases, it is advisable to centralise management in dedicated areas. Otherwise, it becomes necessary to transport fuel to higher floors, along corridors, at the expense of cleaning. With regard to their performance and actual savings, opinions differ, for example, between the young Bongioannini and Ferrini. Furthermore, much of the construction was in masonry, and the technology focused on the stove and on heating of the air rather than on its circulation. This was the focus of research in the '60 s, after the improvements introduced by Meissner in the 1820s (Forni 1997). Indeed, it would be tempting to say that research had ground to a halt: the manufacturers who introduced the most significant alterations, Zanna and Monti, were local, the latter continuing a firm established by Duke Antonio Litta in 1857. The former (Manfredi 2013[49]; Manfredi 2017[50]) probably relied on the Viennese experiences of the *Vormärz* and had established himself in Turin in 1852. The hot smoke of the inverted circulation stove was contained in two kinds of superimposed chambers made from metal sheet. Through these passed pipes channelling the outside air to which the heat was transmitted.

Duke Litta had purchased a French patent (Cantalupi 1862[51]) filed back in 1839 by the engineer Bernard Chaussenot Jr. and, in this case, the stove featured a

[49]pp. 189–190.

[50]p. 53.

[51]p. 493.

hemispherical upper space for collection of the rising smoke, which then passed through a dense series of pipes and descended into a lower, equal-sized space beneath the stove. Each of these firms had headquarters in both Milan and Turin. In the first large, post-unification school building—that of corso di Porta Romana, at the corner of via Rugabella, Milan—the designer (the engineer Agostino Nazari) proposed “Litta system” heaters,[52] while, for the other large complex on via Santo Spirito—via Spiga—via Borgospesso, he repeatedly used Zanna ones, from 1870 to the 1880s.[53] Assignment was awarded through restricted invitations to tender. Alongside the best-known and most technically reliable firm, there was a world of “stove fitters” with shops and warehouses in the old centre of the city; small businesses that assembled pipes and cast-iron sheets or metal plates, perhaps supplied, in part, by larger companies. In other cases, such as Guzzi & Ravizza, a professional who designed the installation competed by probably coordinating workshops that performed the work. This was an initial step towards the birth of a true business. A summary overview of the most innovative companies was provided by Baseggio in the magazine *L'Edilizia Moderna* of 1892 (Baseggio 1892[54]). These were predominantly concentrated between Milan and Turin, but their operating radius, after the unification, was nationwide, as demonstrated by the reference pamphlets printed several times by Litta—G. B. Monti, the Lehmann catalogues and the references included in the Besana & Carloni tenders.

Edoardo Lehmann,[55] who was selected for the schools of via Galvani, proposed a patent filed in Geneva, by Louis Frédéric Staib (1812–1866), a solution also dating back to the 1850s and subsequently perfected (de Candolle 1867[56]; Wartmann 1873[57]). Bongioannini illustrated it and Ferrini described it using the name of Staib’s successors, Weibel&Briquet (Weibel 2006). In a masonry parallelepiped, into which outside air flowed, the stove and smoke evacuation pipes were contained within a smaller, cast iron, concertina-type parallelepiped. This increased the ventilation surface area and transmitted the heat at a lower temperature to a larger quantity of air (Fig. 8).

The commissioners had no doubts despite the fact that the cost exceeded that proposed by Besana & Carloni by 3000 lire, even when, having requested a reduction to 12,500 lire, they had to agree on 13,000 lire. In their opinion, the quality-price ratio was still decidedly superior. *In tempore non suspecto*, the

[52]ACMi, Beni Comunali, Finanze, cart. 209, “Perizia del 28/3/1864”.

[53]ACMi, Beni Comunali, Finanze, cart. 220, fasc. 9, “Prospetto riassuntivo delle quantità delle opere occorrenti per l’esecuzione di parte del progettato fabbricato… di Via Santa Spirito, 23 aprile 1870” and “Scuole in via Borgospesso—costruzione del calorifero, 18-28 luglio 1878”.

[54]pp. 4–6.

[55]The firm was operating till 1906, when was replaced by the firm Haeberlin Gerra & C., (1907–1913), in Archivio Storico della Camera di Commercio di Milano, Monza, Brianza e Lodi, Archivio Ditte. http://www3.milomb.camcom.it/index.phtml?pagina=form&nome=ARCHIVIO_T_Ditte&explode=10.05&azione=UPD&Id_Ditte=27423, consulted on 28/12/2017.

[56]Obituary, pp. 288–290.

[57]pp. 68–69.

technical literature had already adopted a position, by them or by colleagues they cited with the due esteem. In proof of this, Boito entrusted the installations of his last great work, the Casa di Riposo per Musicisti (a retirement home for opera singers and musicians in Milan), to Lehmann.[58]

Of Swiss origin, and a francophone despite his surname, as may be deduced from the rare and minor errors in his clear and correct Italian, Lehmann had established himself in Milan in 1879 as holder of a valued patent. In 1886, he completed his workshop, a block between the present via Lazzaretto, via Casati and viale Tunisia, at that time next to the railway tracks forecourt of the Central Station.

His project report reveals how the literature was transformed into high-quality practice, and how, during this practice, the resolution of certain problems developed. The building would have required six heaters, albeit of different powers, confirming the regulatory limit—15 m—for horizontal air paths. The ducts issued the hot air into the classrooms at 2.5 m above the floor and were constructed from hollow bricks which served as insulation. Additional hollow bricks doubled the solid brick wall of the boiler. Lehmann showed scepticism with regard to the ventilation shafts, which were too numerous—one per classroom—not to impair the function of the spine walls. The extraction activated by gas flame, when the boilers were switched off, would not, in practice, be used, and opening of the windows, which it was impossible to prevent, would, in any case, have undermined its function. As a last resort, it was more advisable to input forced air using a fan operated by gas motor which served to circulate the water, which, pending waterworks with adequate pressure, was, in fact, purchased. *Mutatis mutandis,* the famous alternative of the Hôpital Lariboisière was thus revived (Manfredi 2013[59]).

9 Towards New Climate Control Systems in School Buildings

A useful frame of reference are the conditions desired, more than imposed, by Regio Decreto no. 5808 of 11th November 1888 for school buildings funded by loans partially borne by the State. These regulations finally established a maximum number of fifty students per classroom, recommended separate areas for the changing rooms and a transparent surface equal to a quarter of the floor area, and permitted three storeys in urban centres. With regard to ventilation, transoms were required above the windows. Using heating, temperatures of 14–16 °C (the French standard) should be achieved by inputting air at a maximum of 60 °C (well above the 45 °C limit admissible according to Ferrini) and at a height of three metres. In addition, "the stale air output vents should be set at floor level". This was a

[58]Archivio della Casa di Riposo per Musicisti—Fondazione Giuseppe Verdi, Fondo economato, b.218; cfr. http://lombardiarchivi.archimista.it/fonds/35045 cons. on 30/12/2017.

[59]Overall pp. 135–136 with bibliography for preceding texts.

fragmented, confused and limiting set of instructions compared to the "best practices" of the period, and insufficiently applicable to the schools of smaller centres, the most numerous and necessary.

Another frame of reference is provided by other Milanese schools. Between 1886 and 1889, the director of the via Galvani works, Angelo Savoldi, had built the schools of via Felice Casati, an initial attempt to propose more advanced school building standards.[60] Few documents have been conserved, and it is necessary to refer to the numerous publications,[61] testifying to their success and value as a model. The cost—approximately 454,000 lire—was just under 18,000 lire per classroom, 25% less than Boito's. The transparent surface had been reduced to a fifth of the area of a classroom, and the width of the corridors had been decreased to three metres. Climate control, both active and passive, was more complex: the windows were screened by high, narrow, four-part blinds which could slide in two different directions and back into the wall. The parapets consisted of two slender walls which enclosed a cavity. To the exterior, there was a series of terracotta rose windows. To the interior of these, there was a slit the length of the splay, enclosed by a metal frame with two sliding, perforated plates for blocking or opening the flow of air "like those of railway carriage ventilation doors". Four heaters—one for each wing of the building—were also present, manufactured by Guzzi & Ravizza. The hot air rose in the spine walls and was input into the classrooms at 1.8 m from the floor. In the skirting, on the other short side, were positioned the vents of the ventilation ducts, which rose up to the roof where they joined the chimney flues of the heater boilers, and the hottest smoke activated the outflow. In summer, at the point of the extraction chimney, the customary solution of the gas flame would have been adopted (Figs. 9 and 10).

The air heater, entrusted to Lehmann, appears in one singular case: the Realdo Colombo school in Cremona, whose designer, the city engineer Pietro Ghisotti, personally visited the schools of via Galvani and via Casati and consulted the documentation pertaining they (Landi 2017[62]).

The via Galvani school was opened in autumn 1890, while the rapid population growth necessitated increasingly large spaces. During the second half of 1891, a City Council commission established the relative financial plan for three hundred classrooms over the decade at an average cost of 12,000 lire per classroom, half the amount Boito had calculated. This drastic reduction dictated a further simplification of the already minimal decorations. The changing rooms were renounced, the corridors were reduced to 3 m in width, the transparent surface decreased to a fifth or a sixth of the area of the classrooms, and the height of these dropped to 4.7 m;

[60]The contract with the master builders Maggioni e Mazzai was underwritten on October 20, 1886 and the provisional trial was signed by the architect Giovanni Ceruti, on January 24, 1889 (ACMi, Beni Comunali, Finanze, cart. 223, fasc. 1).

[61]Its most complete description perhaps in Mina (1892).

[62]pp. 162–164.

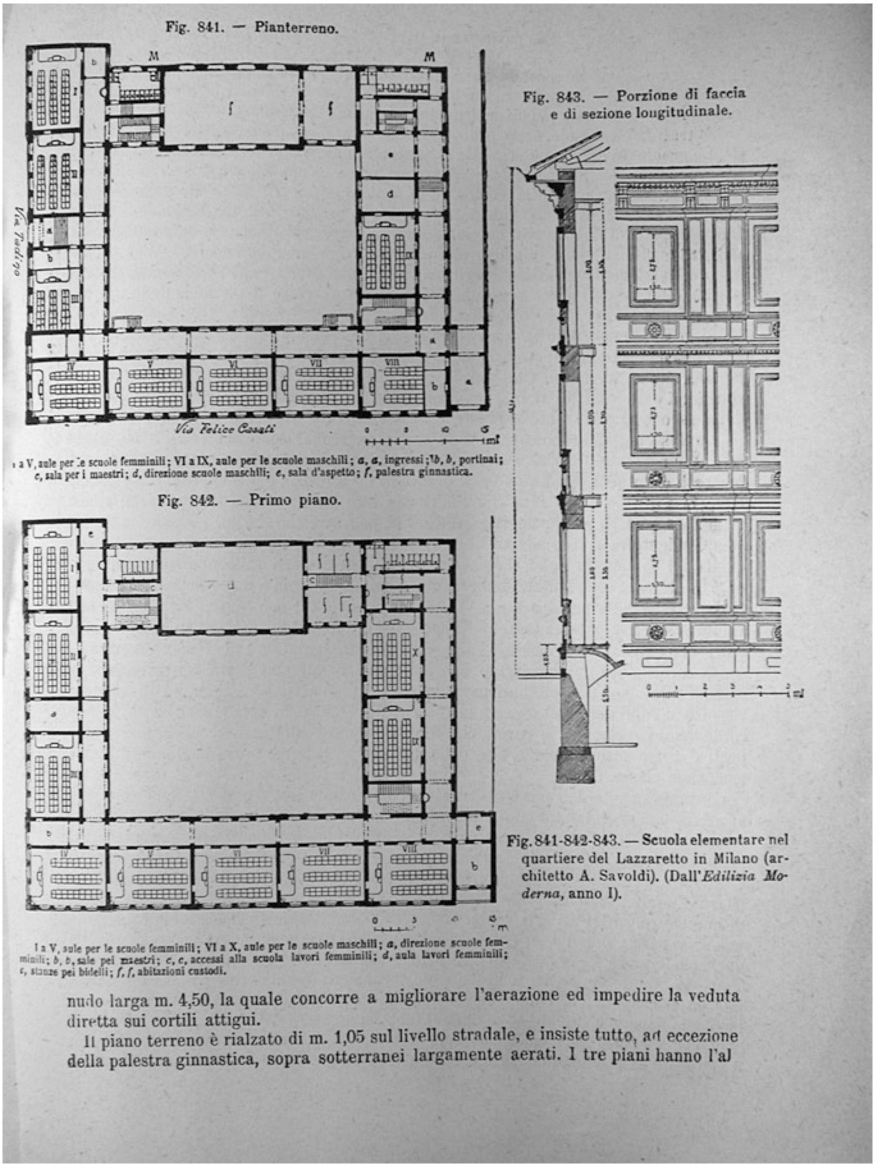

Fig. 9 School in via Felice Casati (Milan, It), architect Angelo Savoldi, plan and building details: *L'edilizia Moderna*, 1892 fasc. V, p. 5

the 30 cm floor permitted a storey height of five metres, a ploy in order to comply with Regio Decreto no. 5808. As far as heating was concerned, the air heater was once again adopted.

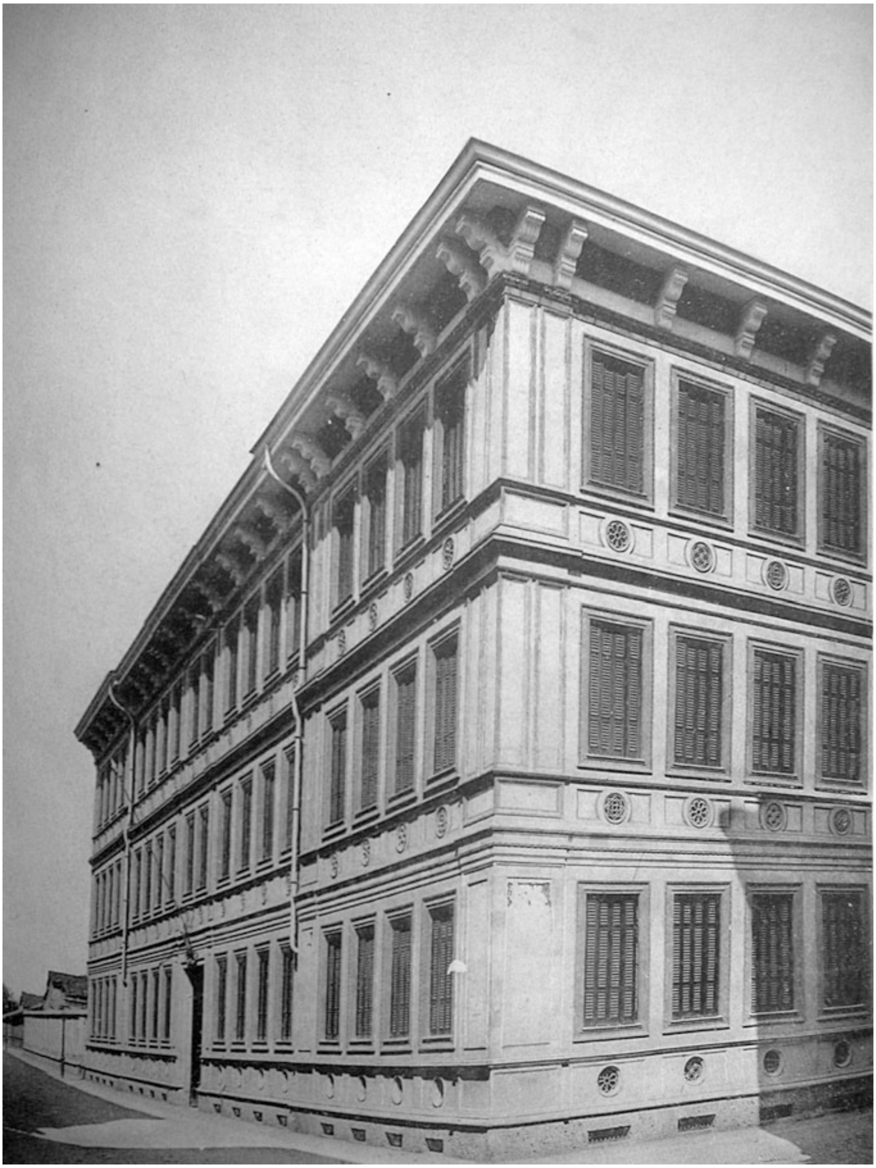

Fig. 10 School in via Felice Casati (Milan, It), architect Angelo Savoldi, front on via Tadino, in: *L'edilizia Moderna*, 1892 fasc. V, tav. XXIII

The extent to which the spending plans were adhered to remains to be examined. Certainly, air heaters were, in more than one case, replaced by steam heaters. In 1893, the company Piazza & Zippermayr,[63] for example, manufactured central heating apparatus costing 26,000 lire for the Via Ariberto School; a single boiler which, however, served no less than 45 classrooms. This was a further step towards the "low-pressure water heating" which would triumph in the following century.

References

Baseggio N (1892) Il riscaldamento a vapore negli ambienti abitati. In *"L'edilizia moderna",* fasc. VIII, pp 6–8 e fasc. IX pp 4–6
Bencivenni M, Dalla Negra R, Grifoni P (1992) Il decollo e la riforma del servizio di tutela dei monumenti in Italia, 1880–1915, vol II, Ministero per i beni culturali e ambientali, Soprintendenza per i beni ambientali e architettonici per le province di Firenze e Pistoia, Firenze
Boito C (1873) Architettura. Relazione di Camillo Boito. In: Relazioni dei giurati italiani sulla Esposizione universale di Vienna del 1873, vol I, fasc 5, Milano, pp 17–29
Boito C (1916) a cura del Comitato per le onoranze alla sua memoria. Allegretti, Milano
Bonghi R (1873) Relazione di Ruggiero Bonghi sulla educazione, istruzione, coltura quale era rappresentata all'esposizione universale di Vienna nel giugno 1873. In: Relazioni dei giurati italiani sulla Esposizione universale di Vienna del 1873, vol I, fasc 1, Regia Stamperia, Milano
Bongioannini F (1870) Riscaldamento e ventilazione dei luoghi abitati: norme pratiche e teoriche per l'impianto dei migliori sistemi: dissertazione presentata da Francesco Bongioannini per ottenere il diploma di ingegnere civile, Foa, Torino
Bongioannini F (1879) Gli edifizi per le scuole primarie [S. l., s. n.], tip. Artero & C., Roma
Bongioannini F (1898) Appunti per la conferenza sul tema Gli edifizi scolastici (Congresso pedagogico Nazionale in Torino, settembre 1898), Grato Scioldo Editore (tip. lit. Camilla e Bertolero di N. Bertolero), Torino
Bongioannini F (1909) Per l'ordinamento del servizio tecnico della pubblica istruzione. Paravia, Torino
Boswell Reid J (1844) Illustration of theory and practice of ventilation. Longman Brown Green & Longmans, London
Brizio E (1872) Scavi nel Foro Romano. In: Bullettino dell'Instituto di corrispondenza archeologica. settembre–ottobre 1872, pp 225–236
Cantalupi A (1862) Istruzioni pratiche elementari sull'arte di costruire le fabbriche civili. Salvi, Milano
Colombo E (2005) Come si governava Milano. Politiche pubbliche nel secondo Ottocento, Franco Angeli, Milano
Cossetto M (1997) Il Museo della Scuola – Schulmuseum della città di Bolzano, i Musei pedagogici dell'Ottocento. In: *Schulmuseum - Museo della Scuola*. Selbstverlag, Bozen, pp 1–4
Cronaca dell'istruzione (1896) L'Osservatore Scolastico, a. XXXII, 10.10.1896 p 12
Curioni G (1873) Costruzioni civili stradali e idrauliche. A. F. Negro, Torino
de Candolle A (1867) Discours. In: Bulletin de la classe d'agriculture de la société des arts de Genève, no. 31, 31 déc 1867, pp 287–292

[63]The contract was subscribed on May 9th, 1893 (ACMi, Beni Comunali, Finanze, cart. 216, fasc. 3).

De Fort E (1979) Storia della scuola elementare in Italia, vol I. Dalle origini all'età giolittiana, Feltrinelli, Milano

Ferrini R (1876) Tecnologia del calore. Hoepli, Milano

Ferrini G (1892) Tipi economici di scuole elementari pel Comune di Milano. Scuole di Via Giusti, Via Torricelli e Via Ariberto. In: *L'edilizia Moderna* 1892, fasc VII pp 4–6 and fasc VIII pp 4–6

Forni M (1997) Il palazzo Regio Ducale a metà Settecento. Considerazioni sulla residenza. Rassegna di Studi - Civiche Raccolte di Arti Applicate del Castello Sforzesco, Milano

Forni M (2017) La stufa alla moscovita a Milano. Applicazioni di un sistema di riscaldamento ad aria calda nei secoli XVIII e XIX, in Manfredi, pp 58–111

Grimoldi A, Landi AG (2014) Structural problems in Italian school buildings of the late nineteenth century: the school "Realdo Colombo" in Cremona. In Meli R, Peña F, Chávez M (eds) Proceedings of 9th international conference on structural analysis of historical constructions, Mexico City, 14–17 Oct 2014

Melis G e Tosatti G (1999) I tecnici delle Belle Arti nell'amministrazione italiana in Varni Melis, pp 183–206

Koller MF (1800) *Der Praktische Baubeamter*, Ignaz Alberti's Witwe, Wien, IInd ed

La Rosa N (2011) Francesco Bongioannini e la tutela monumentale nell'Italia di fine Ottocento. ESI, Napoli

Landi AG (2017) Dalla stufa al calorifero. Il progetto del confort a Cremona XVIII e XX secolo, in Manfredi, pp 144–177

Manfredi C (2013) La scoperta dell'acqua calda. Nascita e sviluppo del riscaldamento centrale, Maggioli ed., Santarcangelo di Romagna

Manfredi C (2017) La fortuna dei sistemi di riscaldamento dall'Europa all'Italia dell'Ottocento: I progetti nei risconttri documentari e nella pubblicistica. In: Manfredi C (ed) Architettura e impianti termici. Soluzioni per il clima interno in Europa fra XVIII e XIX secolo. Allemandi, Torino, pp 19–57

Meda J (2010) Musei della scuola e dell'educazione. Ipotesi progettuale per una sistematizzazione delle iniziative di raccolta, conservazione e valorizzazione dei beni culturali delle scuole. In: History of education & children's literature, vol V, no 2, pp 489–501

Melis G (1996) Storia dell'Amministrazione Italiana (1861–1893), Il Mulino, Bologna

Miano G (1987) Giulio De Angelis. In: Dizionario Biografico degli Italiani, vol 33

Mina C (1892) Edificio per scuole elementari in Milano - Quartiere del Lazzaretto. Arch A. Savoldi, in *L'edilizia Moderna*, fasc V, pp 5–7

Movimento di Provveditori (1908) in "I diritti della Scuola", p 531

Nicolini P, Sicoli S (1978) Verso una gestione dei beni culturali come servizio pubblico: attività legislativa e dibattito culturale dallo Stato unitario alle regioni (1860–1977). Garzanti, Milano

Pisani Dossi CA (1884) I mattoidi al primo concorso pel monumento in Roma a Vittorio Emanuele II. Sommaruga, Roma

Portoghesi P (1968) L'eclettismo a Roma 1870–1922, De Luca, Roma s.d.

Pugno GM (1959) Storia del Politecnico di Torino, Stamperia artistica, Torino

Règlement pour la construction et l'ameublement des maisons d'école,extrait de la Revue Pédagogique, Delagrave, Paris (1881)

Richelmy P (1872) Intorno alla Scuola di applicazione per gl'ingegneri, fondata in Torino nel 1860. Cenni Storici e statistici, Fodratti, Torino

Sacchi A (1874) Le abitazioni. Hoepli, Milano

Sacheri G (1883) Dei migliori tipi di fabbricati per le scuole comunali, Tip. e lit. Camilla e Bertolero, Torino Camilla e Bertolero, 1883. (excerpt from: Le costruzioni moderne di tutte le nazioni alla Esposizione universale di Parigi del 1878, Torino)

Sanzo A (2012a) Studi su Antonio Labriola e il Museo d'istruzione e di educazione. Edizioni Nuova Cultura, Roma

Sanzo A (2012b) L'opera pedagogico-museale di Antonio Labriola. Carte d'archivio e prospettive euristiche, Edizioni Nuova Cultura, Roma

Sanzo A (2017) Il «Giornale del Museo d'Istruzione e di Educazione». Politica editoriale e studi comparativi in educazione. In: Educazione: Giornale di pedagogia critica, vol VI, no 1, gennaio-giugno, pp 100–119

Savorra M (2017) Carlo Lorenzo Francesco Promis, in Dizionario Biografico degli Italiani, vol 86

Scoppola P (1971) Ruggero Bonghi. In: Dizionario Biografico degli Italiani vol 12

Serena T (2000) Scuole Elementari alla Reggia Carrarese. In: Boito C (ed) un'architettura per l'Italia Unita. Venezia, Marsilio, pp 98–102

Serra E (1987) Carlo Alberto Pisani Dossi diplomatico, Franco Angeli, Milano. Le Lettere, Roma

Szambien W (1984) JNL Durand. Picard, Paris

Talamo G (1983) Michele Coppino. In Dizionario Biografico degli Italiani, vol 28

Tauro G (1903) Della necessità di ricostruire in Italia un museo d'istruzione e di educazione. In: Bollettino dell'Associazione Pedagogica Nazionale, no 5, pp 197–227. (published as brochure: Torino, Paravia)

Varni A, Melis G (eds) (1999) Burocrazie non burocratiche: il lavoro dei tecnici nelle amministrazioni fra Otto e Novecento. Rosemberg e Sellier, Torino

Vettori Ardinghi A (2012) Costruzione e trasformazioni di un'opera di Camillo Boito: la scuola elementare alla Reggia Carrarese in Padova, degree thesis, Politecnico di Milano, aa. 2011–2012

Vittanovich P (1885) Le nuove scuole costruite in Padova alla Reggia Carrarese dall'architetto Camillo Boito. In: Il Politecnico - il Giornale dell'Ingegnere e dell'architetto civile e industriale, febbraio 1885, pp 81–92 (published as brochure: Minerva, Padova)

Vitulo C (1993) Riflesssioni sulla vita di Carlo Promis adi documenti della Biblioteca Reale di Torino. In Fasoli V, Vitulo C (eds) Carlo Promis professore di architettura civile agli esordi della Scuola Politecnica, Celid Torino, pp 47–75

Wartmann EF (1873) Notice historique sur les inventions et les perfectionnements faits à Genève dans le champ de l'industrie et celui de la médecine. Genève, Bâle, H.Georg Lyon

Weibel L (ed) (2006) Jules Weibel, un industriel au cœur de l'Europe: lettres à sa famille, 1857–1886. Editions d'en bas, Lausanne

Zucconi G (1997) L'invenzione del passato. Camillo Boito e l'architettura neomedioevale, Marsilio, Venezia, pp 176 and 67–69 and no 10

Zullo E, de Angelis G (2005) Architetto Progetto e tutela dei monumenti nell'Italia umbertina. Gangemi, Roma