

# DESIGN TO THRIVE

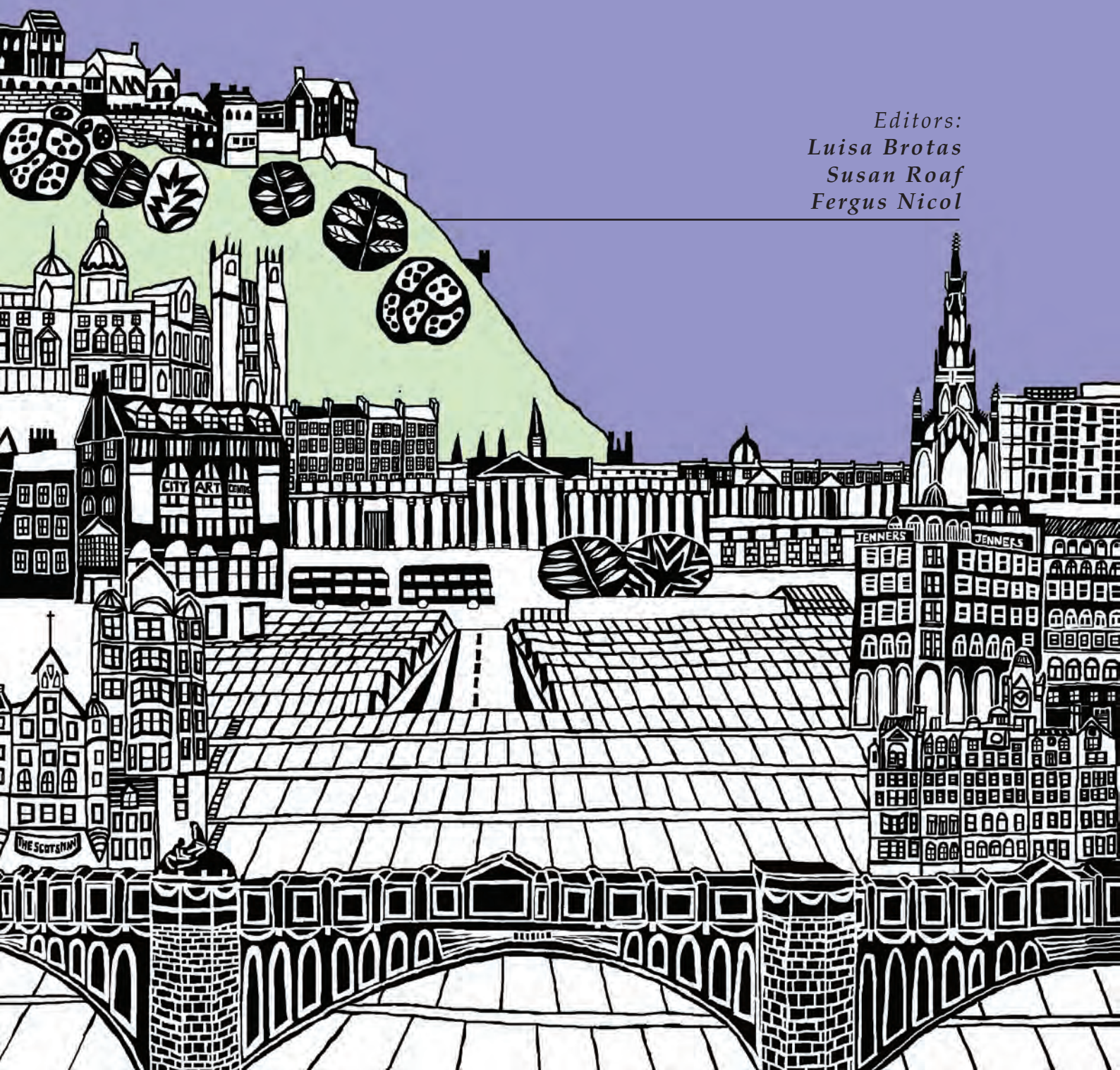
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## *Proceedings Volume II*

*PLEA 2017 Conference*

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# Design to Thrive - PLEA 2017

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# PLEA 2017 EDINBURGH

*Design to Thrive*

## **Sustainable architecture and innovative technologies for deep renovation of school buildings: the design experience in the Environmental Design course of the architecture school at the University of Florence**

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**Abstract:** The paper presents teaching methodology and results of a didactic experience developed in a University course of Florence Architecture School, a Laboratory on Environmental Design focused on deep renovation of School Buildings. These educational buildings represent, in fact, 17% of the European stock of buildings and approximately 12% of average, non-residential, energy consumption in Europe. Furthermore, Europe's school building stock is relatively old and has poor energy performances. The European Energy Efficiency Directive provides that, from 1 January 2014, 3% of public buildings, included schools and kindergartens, should be refurbished every year with a high standard of energy efficiency. However many barriers hamper the implementation of this prevision, in particular the lack of knowledge of new generation of architects, on environmental aspects and innovative technologies, to use in design process to achieve the nZEB targets. To overcoming this gap, the methodological approach of the design experimentation developed during the course "Environmental Design" by the students, focused on following main points:

- 1) Improvement the building's envelope to avoid energy losses in wintertime and improve its performance;
- 2) Improvement of the indoor environment quality regarding to ventilation and passive cooling, daylight, to upgrade the classrooms requirements;
- 3) Improvement of energy generation on site by using active renewable energy sources, beside the passive gains integrated in the school buildings.

This teaching approach has allowed to the students to find new sustainable design solutions that are able to decrease the energy consumptions of school buildings how required from EU legislations and, in the same time, has contributed to shaping a "Thriving Future", by facilitating transfer of knowledge and skills from the market requirements into the design professions, how required from contemporary environmental and societal challenges.

**Keywords:** Sustainable Design Education, Energy Efficiency, School Buildings, Design Studio, Deep Renovation.

### **The Italian educational buildings. A critical analysis of emergencies and opportunities**

In Italy actually there are fifty-one thousand educational buildings: more than half were built before 1976 (the year of first Italian law on building energy efficiency L.373/76); 40% were built before 1971 (the year of first Italian law on seismic safety); and only 9.6% were built between 1991 and 2015, and therefore up to standards in both structural and energy terms (Legambiente, 2016). These data underlines the low degree of investments from the Italian Government in schools during the past twenty-five years and the ageing state of Italian school buildings, and underscores a state of structural emergency which adds to the need for adapting the school buildings, from an environmental point of view, to the new educational guidelines regarding educational programs.

The need to optimize time and costs of retrofitting projects, should also lead to project solutions to integrate in the envelope of school buildings innovative technological solution to: improve the indoor comfort; to increase the mechanical, thermo-hygrometric and acoustic performances and to produce renewable energies. It is necessary, in fact, to resolve the structural lack through financial funds that are able to promote research and projects to find new requalification solutions able to improve the energy efficiency of existing school and/or to design of new ones according to the nZEB standard. Therefore, to reduce the cost of energy renovation of school buildings, it is necessary to find sources or financial support that permit to amortize the initial costs, similar, in some cases, to the price of construction of new buildings.

The safety updating and energy requalification of the school buildings are, in fact, urgent issues to address, both for the Public Administrations and for the sector of scientific research, that from twenty years have been trying to fill the gap of an old national regulation concerning school buildings (L. 412 of 3 August, 1975) developing many research projects on assessment tools, capable of programming a time framework for the schools retrofitting (Renew School, Teenergy School, School of the Future, School Vent Cool, Zemedes, etc.), and on the common ground of a cost-benefit analysis, linked to the possibility to amortize over time the cost of deep renovation through energy savings (Energy Concept Adviser for Educational Buildings and VERYSchool, etc.).

It is fundamental for the professionals involved in the retrofitting process to learn how to participate, from the preliminary phases of the project, together with the public administration, in the choice of non-repayable and/or low interest rate financial support that allows obtaining a reduction of the investment necessary for the fulfilment of specific energy and/or functional and/or structural objectives. Moreover, this economic instance determines projects, which already from the concept phase, must be developed in the same time of an energy analysis carried out together with an assessment that permits both energy saving in terms of heating, cooling and lighting, and access to possible national and/or international fiscal bonuses.

In addition, the urgency of the emergency and the need to respond to international educational guidelines should induce professionals in the construction sector of school buildings to find new answers also through innovative spatial solutions, capable of transforming educational environments into dynamic and multi-functional dimensional entities. The sequence of the different educational moments, which require variable student-teacher or student-student settings, is, in fact, at the base of an innovative idea of the school building, which must be capable of guaranteeing the integration, complementarity and interoperability of its spaces, including the use of new technologies. The schools of the future must, in fact, become Smart Schools, where will be possible to use intelligent devices in order to improve educational activities. Furthermore they should be able to reflect the innovative and sustainable features of the Smart City, where the Educational System acquires a strategic role in the urban policies in order to build opportunities and projects for a green city. In this future vision of our cities the school buildings will become strategic hubs capable of generating educational and participative processes, involving the community towards the adoption of new lifestyles, in which citizen will be able to share technological growth, urban transformations, and economic, social and cultural changes.

Starting from these analysis of the state of the art in the frame of retrofit and design of school building in Italy, this building typology are chosen as design topic and as case study in the seminar carried out at the Environmental Design Lab of the degree in Architecture of



the University of Florence. The seminar on school buildings, in fact, it is originated in the need to give concrete and innovative answers to the state of energy and structural emergency in which educational buildings find themselves, both in our country and in all Europe.

### **The Seminar on deep renovation of School Buildings**

The architectural research seminar “Sustainable architecture and innovative technologies for deep renovation of school buildings” has been part of the didactic experience developed in the Laboratory on Environmental Design of the Department of Architecture in the Florence University, in the Academic year 2016-2017.

The research and the teaching activities have been focused on the topic of deep renovation of school buildings located in Med Area. The goal of the seminar was to promote the challenges of sustainability and retrofitting, developing a new design approach and new professional skills for the architect of the future that will be called to work in these design area.

During the Seminar the students have analysed three case studies of schools provided by a Public Administration, the Municipality of Lucca (LU), which has supported the academic work, offering the opportunity to develop real projects of deep renovation.

The projects outcomes were innovative design solutions that could be repurpose also in other retrofitting project of school buildings. The work developed during the seminar was linked to the specific geographical, economic, cultural and social condition of Europe School Buildings stock and in particular wanted to answer to the Energy Efficiency Performance Building directives on the topic of build a new generation of nearly Zero Energy Buildings.

### **The case studies**

In response to the request from the Municipality of Lucca, involved in the Environmental Design Laboratory as virtual customer, the students worked on the renovation and expansion of three educational buildings, choices as case studies and following described:

#### ***The primary school and nursery in San Cassiano a Vico***

The elementary school is organised into five classrooms of approximately 40 m<sup>2</sup> each, and into: a room for fitness activities; a library; a computer Lab and a canteen. A large covered foyer, which is destined for group activities, connects all spaces in the ground floor. The nursery is organised into three sections placed around a central courtyard for open-air activities; the structure is completed with a small canteen that includes a kitchen for preparing meals. The technological features of the two buildings are: Reinforced concrete structure, that determines the formal uniformity of the spatial distribution; Walls made of plastered perforated bricks without insulation; Windows with frame in aluminium without thermal break and single glazing; Ribbed-slab floors without insulation.

The school has high-energy consumptions for heating. Furthermore, it is too small in view of the growth expected by the Municipality, who would like to transform the existing structure into a proper Educational Complex in which to relocate another Elementary School that is located to 2.5 km from the area of project.

In particular the Municipality want develop a design project for the deep renovation of the existing buildings and for the construction of a new building (with a surface of 450 m<sup>2</sup> distributed on two floors), where to place: a canteen (150 m<sup>2</sup>); a classroom for physical activities (145 m<sup>2</sup>); toilets and storage rooms.

### ***The primary School in San Donato***

The San Donato building has only five classrooms. Functional spaces (as canteen, gym, laboratory, etc) for organising full-time activities are missing. In particular the pupils must eat their meals in the classroom because of the absence of a canteen, with a psychological discomfort in order to carry out their educational activities. To solve these problems the Municipality of Lucca asked us to design a new building located in the south area of the school, connected to the existing one through a covered tunnel. In this new block (450 m<sup>2</sup>) should be placed: a canteen (150 m<sup>2</sup>); two laboratories (50 m<sup>2</sup> each); toilets.

### ***The primary School in San Marco***

The San Marco school is located in via Baccelli in Lucca and consists of three blocks built in different times, more precisely: 1) in the Sixties, the building where are located three sections of the nursery school on the ground floor and the offices of the school secretary on the first floor; 2) in the Seventies, the building where are placed the canteen and related services, and the classrooms; 3) in the Eighties the building where are placed a gym for the use of both the school and the neighbourhood. In the last year it was necessary to place three new classrooms in the atrium of the ground floor of the block built in the Seventies, decreasing the space to use for recreational activities of the students.

The need to solve the problem of space and to transform the San Donato primary School into a School Complex where will be possible moving also other primary schools placed in other buildings do not belong to the Municipality, has led the Lucca Public Administration to reflect on the necessity to expand the existing building with a second floor over the central one-store section. The request was thus that of re-qualifying the existing building by constructing an additional volume of 300 m<sup>2</sup> of useful surface within which to place five new classrooms provided with a double set of toilets for males and females. Thanks to this expansion it will be possible to recover the three spaces that are currently destined to educational activities on the ground floor, so as to create new space for activities that are complementary to the educational function, in accordance with modern educational guidelines.

### **Teaching Methodology**

To overcome the gap of absence of technological solution and design methodology to answer at the structural emergency that characterizes the school building sector, the methodological approach of the design experimentation developed during the Laboratory of Environmental Design was focused on following main points: 1) Improvement of the building's envelope to avoid energy losses in wintertime and improve its thermo-hygrometric performance; 2) Improvement of indoor comfort regarding ventilation and passive cooling, daylight, to upgrade the classrooms requirements; 3) Improvement of energy generation on site by using active renewable energy sources, beside the passive gains integrated in the school buildings.

This teaching approach allowed the students to find new sustainable design solutions that are able to decrease the energy consumptions of school buildings as required from EU legislations and, in the same time, has contributed to shaping a "Thriving Future", by facilitating the transfer of knowledge and skills from the market requirements into the design professions, as required from contemporary environmental and societal challenges.

The possibility to develop three projects for three real case studies, provided from the Municipality of Lucca, was an excellent opportunity to enable students to "learn to work in

the complexity, experimental manner in real conditions of the project (Torricelli, 2011, pp. 21)", dealing with " a broad and trans-disciplinary context focused on knowledge, methods and tools to respond to specific verifiable parameters" (Lo Sasso, 2011, pp. 83).

In detail, thanks to the need to design in real situations, it was possible to set the discussion on the environmental project "based on a systemic and performance disciplinary approach within the process stages related to the design, production and management of works and artifacts (Lo Sasso, 2011, pp. 82)". This methodological approach allowed the young architects to "express their project ability according to a knowledge and progressive 'revelation' (Heidegger, 1976, pp. 9, 10) path, in which have a prominent role activities, timing, cost, quality, and aspects of production, management and operations, whose declination takes place also on the basis of experimental and innovative instrument or the verifiability of the results. (Lo Sasso, 2011, pp. 82)

The design of the three school buildings was developed according to Italian regulation on school buildings (L. 5/7/1975) and to the recent draft of the ministry's Guidelines on school buildings (D. M. 11/04/2013), as well as to the regulations regarding energy savings (L. 195/2005 and subsequent modifications and additions), the accessibility of public buildings (L. 13/89) and fire and seismic safety, with a focus on the topic of environmental, social and economic sustainability.

The guidelines of European Directives 31/2010 and 27/2012 were followed, with a strong orientation toward Deep Renovation actions, capable to change existing buildings into near zero-energy buildings. Additionally the students have analyzed the case studies at the technological detail's scale, with the objective to choose systems, as well as building envelope and equipment components in order to guarantee the energy autonomy of the school buildings, and allow the production of renewable energy also, so as to reduce environmental pressure within the urban area of the project.

The teaching methodology was focused on the design process based on three steep of technical definition corresponding at three different scale of technological detail, as envisaged by the Italian regulation named Ex-Merloni (Act n. 109 of 11 February 1994, "Framework regulation regarding public works"): 1) Preliminary Design Phase, regarding the development of urban and environmental analyses, design schemes and preliminary dimensional assessments; 2)) Definitive Design Phase, regarding the development of the technical drawings necessary for describing in detail the project in its geometric-dimensional features; 3) Executive Design Phase, regarding the development of technological solutions, concerning the building envelope and systems, using graphs and digital rendering that describe the construction and management phases.

The need to compare the design process developed during the seminar with a scheduled program that replicates the time-frames and methods typical of the architectural profession, has allowed to stimulate the students to undertake a "process of problem identification and analysis; idea generation; gathering, analysing producing and coordinating information; turning it into knowledge and using it to make the process of building more effective, with the ultimate aim of pleasing clients and providing exciting, vibrant, sustainable and healthy environments for all those who use them (Emmitt, 2011,pp. 50)".

According to the requirements of the Municipality of Lucca and with the methodological approach developed in the Laboratory of Environmental Design, the students were asked to: 1) Design the new buildings addition, with the use of innovative, anti-seismic, ecological and efficient technologies, in order to reduce the energy consumptions for heating and cooling during all year; 2) Integrate on the roof of existing and new building, PV panels for producing

the necessary electricity for running a heat pump to provide heat for low-temperature heating systems; 3) Refurbish the envelope of the existing buildings, to improve their energy performance and changing their architectural appearance; 4) Increase the volume of the school building (20%), through the design of integrated greenhouses.

Furthermore the student has been invited to develop their projects to answer at the topic of the Competition of Ideas “The Good School”, issued by the Italian Government in the autumn of 2015, and focused on the followings objectives:

- Reflecting on the need to design innovative, flexible and user-friendly educational environments, designed in accordance with educational needs;
- Designing spaces for educational activities from the point of view of indoor comfort and social interaction;
- Reflecting on the need to design attractive spaces to contrast the phenomenon of educational dispersion;
- Promoting environmental, energy and economic sustainability through a swift building process and use of recycled materials and renewable sources;
- Promoting a major opening of the school toward the territory, thus transforming it into a vital centre and a point of reference for the community;
- Guaranteeing the presence of spaces for teachers devoted to professional collaboration and individual work;
- Including places dedicated to research, such as libraries and study areas;
- Devising a greater flexibility in terms of opening times so as to be able to use spaces after school for carrying out several activities, thus also allowing money to come in for maintaining the structure;
- Designing buildings conceived as educational tools: aimed at developing both technical and sensory competencies;
- Ensuring the presence of green areas: rethinking the relationship between the building and the surrounding natural environment depending on teaching and learning activities.

Finally the students had to develop their project following a required/performance approach, with the goal to design smart and flexible spaces, functional to the most advanced teaching and learning systems. Environmental adaptability had characterized, also, the design of outside spaces too, reconfiguring the schools case studies as “Civic Centers”, able to become an urban catalyst, valorizing social, cultural and educational instances. A special attention was placed to the link between the design of the new volumes and the existing buildings, and between the project as a whole and the environmental and urban context of reference, including, when possible, new functions that provide opportunities for usage outside of school hours and by external users.

## **The results**

All the young architects involved in the seminar have approached to the project with awareness and attention:

- The students that addressed the issue of the expansion and retrofitting of the San Cassiano a Vico school, chose the solution of ventilated facade with coloured panels in wood-based fibres and thermosetting resins for the renovation of the existing envelope and for the construction of the new school block, providing it with a solar greenhouse capable of interacting with external climate conditions.



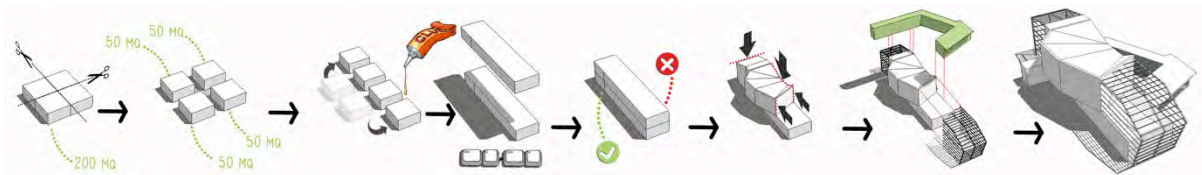


Figure 1. Concept design of the new building for the Primary School San Cassiano a Vico

- The student groups involved in the deep renovation and in the new construction of the Primary School of San Donato, have proposed solutions characterised by the choice of drywall construction systems with the purpose of reducing times and costs of the construction and to guarantee the formal continuity with the existing building, thanks to the possibility of replicating in series the building envelope solutions, both in the expansion and in the retrofitting.

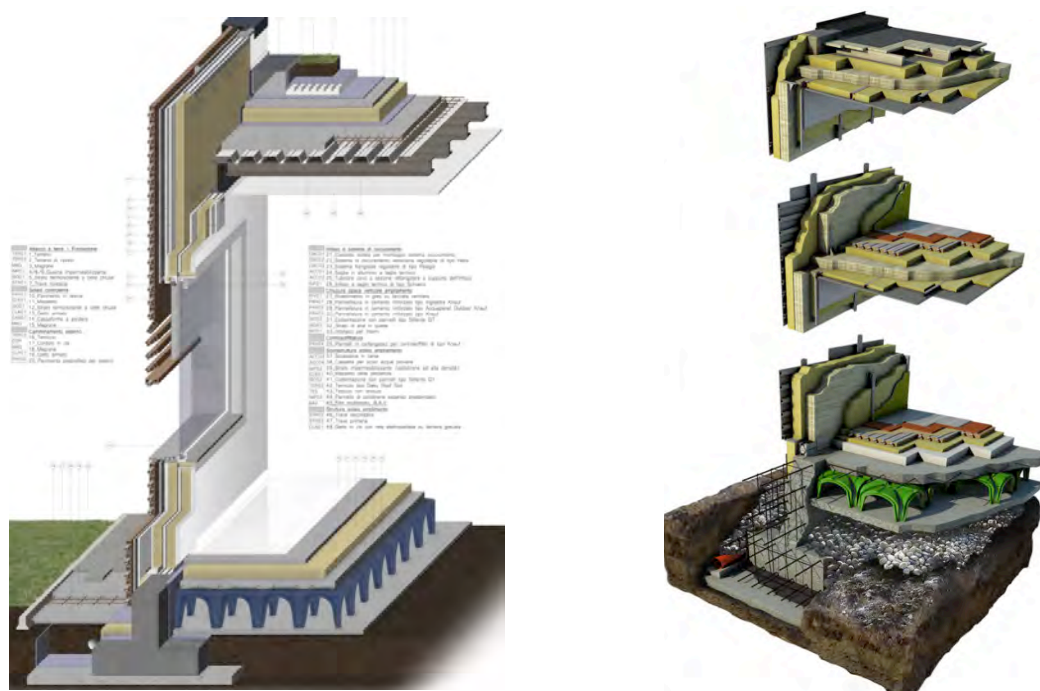


Figure 2. Technological details of the envelope solutions for the renovation of Primary School of San Donato (left) e San Cassiano (right)

- The students who were involved in the requalification of the San Marco Primary School carried out a careful assessment of energy consumptions, developing a project focused on the radical transformation of the architectural appearance of the building by the integration of an external shading device built with micro-perforated aluminium panels, capable of changing building configuration in accordance to the incidence of solar radiation.

## Conclusions

The excellent results obtained with the project developed during the Seminar activities show how the theory applied to the development of the design phase, led the students to re-think the approach to the project on the basis of the necessary environmental reflection, assessing architectural compositional, formal and technological choices; a new professional awareness that is independent of the simple aesthetic and dimensional results. In addition, the possibility of verifying technological solutions through the use of appropriate software and the constant

reference to Environmental Control Techniques discipline, permitted the young architects to understand the need to combine the creative moments with quantitative validation ones, in order to guarantee the choice of the scenarios and configurations, with a lesser impact from the point of view of the entire life-cycle of the building.

Therefore, effective and environmentally sustainable technology solutions become closely linked and integrated into architectural design solutions, often justified by a cost-benefit analysis indicating students' sensitivity to issues related to the cost of managing and maintaining public assets. Since the project concerns school buildings it was in fact fundamental to reflect on the necessity to adopt materials, systems, components and equipment that guarantee durability and easy maintenance, as well as an excellent level of indoor comfort in both the existing and new school spaces.

The projects developed in the Environmental Design Lab were capable of going beyond the simple academic approach, turning them into true projects with a level of detail and originality and in-depth analysis capable of being transformed into architectural solutions ready to be carried out and applied by the Public Administration. The quality of the results validated the choice of teaching methods, which has contributed to increase the cognitive maturity of the young architects linked to the technological and environmental choices made at the design scale. The aim is that this experience, which hopefully will not be an isolated case in their cultural baggage, shall help them to reflect on the element of ethical commitment of the professional role that they are called to carry out in the years to come: a role that requires an increasing degree of specialisation and care at the scale of technological detail for the integrated project, but especially of responsibility towards choices that can have irreversible effects on our future and on that of following generations.

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