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Creating Sustainable Development

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Contents

Chapter 18
Green Lab: A Strategic Design Framework to Develop Sustainable Research Laboratories

Rosalba Belibani, Elena Gigliarelli, and Jody Patterson

Abstract The aim of this paper is to present a system of design strategies, useful to technical institutes and universities, that endeavor to create more environmentally and socially sustainable laboratory spaces.

The Green Lab model is designed to promote sustainable education throughout the complete life cycle of smart buildings. This requires a critical departure from traditional practices, starting at the formative stage, as defined by Edward Mazria's 2010 Imperative and 2030 Challenge (http://architecture2030.org/): first the change required in education, making ecological literacy a central tenet; then the change enabled in design, required to reduce CO_2 emissions by building activity by 50 %. Green Lab assumes an alternative approach to design education, to deliver different results—rendering the education process itself innovative, interactive and sustainable, and demanding smart buildings with the same characteristics.

The Green Lab methodology has been developed through teaching and research experience, providing a forum to apply and test design principles and innovative construction technologies as well as an occasion to propose a shift in cultural paradigm, so that university and research institutions themselves become prototypes in the field of sustainable building and energy technologies. The building project must constitute an innovation epicenter for the study of sustainable technologies, representing in itself a testing ground for advanced "solutions in progress" which are continually integrated, evaluated and replaced.

The result of this sustainable education model is the design of an architectural organism conceived according to bioclimatic strategies for minimal environmental impact, using recycled materials and meeting the highest standards of energy

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efficiency—a Green Lab capable of sustaining itself, generating energy from renewable sources via its form, surfaces and volumes. The knowledge base of the design laboratory is in constant expansion, requiring active research contributions (via dedicated website DiarAmbiente) from all participants: students, professors, architects, engineers, and national researchers collaborate directly to maintain a highly dynamic multilateral learning environment, keeping the moving target of sustainable design in focus. Its outcomes are high-level design projects, demonstrating increased consciousness and commitment to sustainable building.

Keywords Sustainable education • Design studio • Research project • Green Lab • Adaptive reuse

18.1 Background

The initiative to start a research project within a design studio context—founded upon the themes, methodology, content and goals of sustainability education—came after a long process of enhancing ecological literacy in collaboration with Anna Gadola and Franca Bossalino, and expressed in the research published on the website DiarAmbiente [1].

In May 2005, American architect Edward Mazria challenged the international building community to take the lead in combating climate change. In June 2005, sixteen of the most important institutions worldwide in the field of architectural education signed the Declaration of Las Vegas, recognizing "the great responsibility that rests on the architectural profession to do everything possible to influence a significant reduction carbon emissions resulting from construction and the life cycle of the built environment."

In 2006, Mazria launched Imperative 2010 online—regarding the change required in education, whereby ecological literacy must become a central tenet of design education—along with the 2030 Challenge [2], to change building design in order to achieve a 50 % reduction in the level of CO_2 emissions produced by the building industry. The DiarAmbiente site was born thus, with the conviction that we can develop all of our theories into practical application within the Design Studios of the Architectural and Urban Design program, held for 2 years, within the 5-year degree course in Architecture of the EU at the Faculty of Architecture at Sapienza University of Rome.

18.2 Problem

It was decided to target the entire design studio experience—both teaching and learning—in order to integrate and develop the complex aspects of sustainability. The most difficult challenge to approach was to conceive a teaching methodology

that could be called sustainable within the context of the teaching tradition, coexisting with the difficulties inherent to the teaching discipline. The design exercises to be assigned to students were more easily identified and treated in an articulated manner:

- 'Ecological literacy' education as a central principle in ecological design project, aiming to reduce CO_2 emissions by 50 %.
- Deepening of technological and engineering aspects within an architectural language where form follows not function, but the evolution of the project.
- Analysis of the relationships between the project and its locality.
- Technical analysis of the composition process, highlighting the complexity of the design process wherein practical skills and theory must feed each other.
- Attention to all aspects of the environmental sustainability of the project which inform the architectural solution.

The final design project assigned was a scientific research laboratory facility, characterized as an artificial lung, with a contemporary and technologically advanced architectural structure, to be achieved on the site of the National Research Council of Rome (CNR) in the municipality of Montelibretti: a scientific campus of 70 ha, including 15 institutes and over 500 employees.

To ensure realistic adherence to the aims of the project, the teaching staff was enhanced with the participation of Arch. Luciano Cessari and Arch. Elena Gigliarelli, both of CNR-ITABC, and Jody A. Patterson, Visiting Professor at the Faculty of Architecture, as well as other staff with experience in teaching design, sustainability and sustainability assessment via LEED and ITACA protocols.

The assignment was to design an architectural organism, incorporating recyclable materials and the latest solutions for reducing energy use and implementing energy from renewable sources, characterized as a "green laboratory": a Green Lab with low environmental impact, which can sustain itself from an energy standpoint. The building must be a center for the study of innovative technologies in sustainability, applied to the understanding, conservation and renovation of our built heritage, representing in itself a prototype "in progress" for technologically advanced solutions, to be continuously integrated or replaced.

18.3 Context

Redeveloping an area of the National Research Council site was, therefore, the issue addressed in the Design Studio, for which students were encouraged to experiment with the design of new models of buildings for researchers and scientists, utilizing the latest solutions for energy saving and use of energy from renewable sources.

Teaching goals were established to elaborate a joint project, accomplished through a complex systems approach, to create new workspaces for scholars and researchers while at the same time leading to the improvement and enhancement—

on an environmental, landscape and architecture basis—of this important Italian Science and Technology Park. The aim of this design project is to improve the quality of research and sustainability of the entire complex, via a systematic and coherent set of interventions on existing buildings, open and green spaces, but also to develop a model for science parks (CNR research area of Rome) that encourages cooperation between public research universities, public and private industry. Research laboratories so designed can encourage interaction between scientists from various disciplines, promote the recruitment of top researchers and facilitate the association and development of scientific activities. The challenge in designing a laboratory for scientific research contained in a contemporary and technologically advanced architectural organism, involved the creation of a self-sustaining low-impact "Green Lab."

18.4 Approach

The design studio, which aims to provide students with the theoretical knowledge and practical skills necessary for project development, is traditionally organized into lectures, exercises and design activities in the classroom. Usually, the student is a passive subject during lessons and intervenes only during reviews, showing the progress of their project. To transform, therefore, the design studio into an educational experiment—as sustainable as possible—we attempted to shift the student into an active role, taking a share in the teaching work from which the student is traditionally excluded. Sustainable design issues approached during the course were developed through the following activities:

- Three interim hand-ins of maquettes at different scales.
- Various tutorials on complex topics agreed with or chosen by the student.
- Presentation of systems for assessing the sustainability of a project, both specific to Italy (ITACA) and international (LEED), applied as an analysis exercise to projects chosen by the student.
- Ongoing reviews to check the progress of individual projects and permit a more personal relationship between teacher and student.

Students were also required to keep a studio album in which to collect notes, drawings, thoughts, ideas, sketches, impressions, images, references to other projects or specific theoretical references.

Two introductory lectures were delivered by Professor Franca Bossalino, long engaged in a campaign to improve the ecological literacy of architecture students. Within the Architectural and Urban Design IV studio, which served as a testing ground for this new approach to sustainability as applied to didactic activity and content, there are two Training Modules (approximately 30 h each) of "Systems" and "Technologies," which, in applying a structured model for sustainable education, offered substantial contributions to the development of an integrated design project.

The architectural project was developed during three intense months, taking a holistic approach and applying bioclimatic design processes governed by effective elements and best-practice solutions for sustainable design (buffer zones, curtain walls, green roofs, green walls, use of geothermal energy, appropriate use of integrated solar panels, etc.) The course website also provided a means to share the extensive and detailed bibliography and an notable collection of web-links with important information for project development.

18.5 Methodology

Studio teaching was approached as an experiment to define a design methodology around innovative and sustainable laboratories, to be implemented at a Science Park operated by Italy's most significant research agency. Choosing the CNR Rome site for the Studio intervention gives strict boundaries to the development of the theme, based in thorough analysis of the context and the scale of the intervention area. An environment of 70 acres at high landscape value, veined with a network of laboratories and scientific institutions developed in various phases over 40 years, posed the problem of supporting critical functionality of these headquarters while enhancing the area as a green and attractive place for research excellence: seeking an architectural intervention that can begin a process of regeneration of the entire campus.

The theme of the redevelopment of the site thereby intersected with a teaching methodology aiming to develop sustainable solutions and models for a new type of research laboratory, a "social incubator" that encourages interaction and team-based research, while providing the flexibility to allow ongoing evolution and change (Fig. 18.1).

Departing from the classical approach of functional laboratory, the research site was no longer seen as a machine for the development of techno-scientific processes but as a place of intellectual work and open and flexible experiments, connected to social and scientific networks and populated by "nomadic workers," operating within a crowd sourcing framework that foresees the collaboration of many researchers who via these networks will accomplish a particular job—all of this with obvious reflections on building design and architectural solutions.

It was therefore requested that the proposed project express levels of in-depth research and design on the following topics:

1. A Green Lab, called "LARIS Laboratory for Interactive Research on Sustainability."
2. A Science Center.
3. The archaeological museum display area of Colle del Forno.

Fig. 18.1 Master plans

18.5.1 LARIS Green Lab

The LARIS Green Lab was thought of as a 'living laboratory' in which researchers and partners in conservation can carry out research and evaluation on current and future systems and technologies at a high degree of performance and sustainability. In this sense LARIS will be used as a platform to test and demonstrate the technical performance and usability features of their technologies and systems. Product evaluation (via technical analysis and compatibility testing) performed by an independent public research entity can reduce the public burden of product development and create early market demand. Advanced visualization systems and simulation technologies will be used to involve all those involved in conservation efforts for built heritage (architects, restorers, superintendents, manufacturers of environmentally sustainable materials, etc.) (Fig. 18.1).

18.5.2 Science Center

The architectural organism assigned also had to include a Science Center, able to promote the dissemination of scientific research findings and discoveries in the very facility and in the field of sustainability, as well as those developed in other institutions in the area. This "Thematic Center" was to open to the public the contents of discoveries and innovations in this field, proposing itself as a platform for communication and exchange between the institute and the scientific community. To satisfy these needs, a room for multimedia exhibit was also requested for the display and dissemination of scientific culture: a place to perform interactive simulations of the performance and use of the building and explore alternative scenarios with sustainable strategies. This should include: a multimedia theater featuring advanced visualization (high-quality, high-scale screens to exhibit graphics and audio) and technologies of interaction with the public; reconfigurable

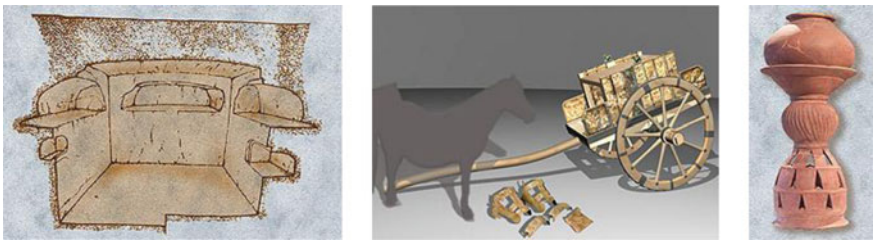

Fig. 18.2 Archaeological context

screens to maximize flexibility and allow experimentation with this same equipment; fixed seats with LCD touch screen panels wired for interactive participation and interconnected to a large screen display.

18.5.3 Colle del Forno Archaeological Area

The architectural design was also to include a hypothesis for the linking and integration of the new complex with the archaeological area called Colle del Forno, located on the crest of a hill that dominates the area, represented by a pre-Roman necropolis and currently inaccessible to the public. To relate the building organism with the necropolis, an open-air museum display area was called into play to provide a system of trails and facilities for visiting and reading in experimental ways (Fig. 18.2).

Laboratories constitute a unique challenge for sustainable design because of their intense energy use, stringent health and safety requirements, and complex environmental systems. Because of this, growing public awareness of sustainable design and construction has not gone unnoticed by the scientific community. The U.S. Green Building Council (USGBC), the Leadership in Energy and Environmental Design (LEED) program and the EPA/DOE's Labs21 were considered as guides and organizational tools supporting the sustainable design process for this specific area. From a spatial point of view the building must achieve an appropriate balance between open and closed type laboratories, developed on one or more levels, integrating with other agencies and with the surrounding topography, structured and populated with existing and new vegetation. The results of this Design Studio have shown a panorama of architectural solutions in which these scientific buildings were linked to issues of environmental sustainability and energy savings.

18.5.4 Program Requirements

Student projects must include the following components:

- Structured spaces for technology labs.

- Flexible wireless space for researchers.
- Multimedia center for technology simulations, design and science exhibits.
- Space for meetings and conferences.
- Offices for management of activities.
- Common areas.
- Toilets, a kitchen etc.

18.5.5 Project Requirements

Students were required to design a building defined by function rather than style, that can either be characterized as a strong architectural landmark—distinctive of the CNR campus—or as a compositionally light structure, morphologically and most of all ecologically. Technologically, the building must be designed as a living organism, able to generate energy via its own form, mass and volumes, utilizing primarily passive design strategies and systems. High level sustainability can include advanced water recycling systems and natural ventilation, favoring daylit interiors (Fig. 18.3).

18.6 Results

The results achieved by the final projects submitted were all of good quality, with a notable percentage of high quality, convincing the faculty to proceed with this teaching method. With regard to the project requirements in terms of sustainability and energy conservation, it is necessary to state that students have shown themselves highly receptive and capable to acquire a new design language, inspired by the themes proposed by the innovative use of bioclimatic strategies and skilful application of materials and vegetation. Even the interiors, which required some degree of design has been developed to the satisfaction of the choices made by the student.

18.7 Conclusions

This research shows its originality not only in the approach to teaching sustainability issues, but, of course, in the strategic content of the Green Lab projects themselves and especially in the teaching methodology used, unequivocally confirmed by the value of its results. All areas of the research support the potential for future development and areas of application.

Fig. 18.3 Sample of student work

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