

Solar house prototypes as *living labs in architecture* for holistic sustainability education

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Abstract

The LOW3 prototype solar house of UPC has been designed and built between 2008 and 2010 and converted and operated as a *Living Lab for sustainable architecture and lifestyle* since 2011 at the ETSAV campus at Sant Cugat del Vallès (Barcelona) under the responsibility of the author (www.livinglab-low3.blogspot.com)

This paper highlights the importance of *Living Labs* as innovation infrastructures in Higher Education and presents the specific educational experience of LOW3 within the institutional framework of UPC, drawing from 5 years of action research regarding pluridisciplinary, experience based sustainability education.

Keywords: *Living Labs, Education for Sustainable Development, Sustainable Lifestyle, Sustainable Architecture, Solar Architecture*

1. Background

Education at schools of architecture must attend the demand for a new profile for architects, integrating and fostering corresponding SD competences through new learning methodologies, tools and concepts (EDUCATE Project Partners 2012). A series of recent developments give relevance to the research on *Living Labs in Architecture* as new tools for a holistic Education for Sustainable Development (ESD) with a specific focus on renewable energies in housing and our daily lives:

- A new educational reality, with redefined objectives in higher education based on competence-based learning and a more transdisciplinary approach
- A new knowledge reality, with an urgent need for acquisition of new knowledge regarding specific subjects like low energy buildings, low-impact building materials and energy efficient technologies
- A new social reality, shifting towards participation, constant social innovations and a higher demand for environmental standards
- A new professional reality, requiring more interdisciplinarity, the ability to deal with complexity and uncertainty and new forms of project development processes based on collaboration

Important considerations regarding the essence of ESD are furthermore the understanding of sustainability as a (socially constructed) reality, "... as a dynamic and/or evolving concept, as controversial and the source of conflict", and as a "catalyst for change" (Wals & Jickling 2002), which in consequence needs places for its collective negotiation and definition. This might require a new form of collaborative and empathic learning in order to develop a new collective "*biospheric consciousness*" (Rifkin 2011). Finally ESD seems to require so-called "*transformative learning*" based on psychological, convictional and finally behavioral transformation (Wiek et al. 2011, Boehnert 2012). On the other hand a newly strengthened social responsibility of university towards society in the development of innovative solutions for our environmental, social and economic conflicts must lead towards new processes in teaching, research and technology transfer based on a strong interaction with their local and regional communities and society in general (Cortese 2003). Living Labs seem to play here an interesting role as collaborative multi-stakeholder platforms.

2. Introduction

In the area of architecture, the ETSAV School of Architecture at Sant Cugat del Vallès can be considered a pioneering institution in understanding its campus and buildings as a laboratory to learn about energy efficiency in buildings, but also its community as an important stakeholder for a broader approach to sustainability regarding its socio-economic environment.

Solar Decathlon is an international competition for 20 selected universities to plan and build prototypes of energy self-sufficient solar houses. In 2008 a first ETSAV team under the lead of the author started the development of the first prototype solar house LOW3 at the campus in order to participate in the Solar Decathlon Europe 2010 competition in Madrid (Masseck 2011).

The LOW3 project (2008–2010) demonstrated over a 2 year period the importance and impact of a new way of education in architecture, based on the development and construction of a prototype house at the campus with a high degree of team self-organization, individual responsibility, and a strong link between teaching and research.

LOW3 has been reconstructed in 2011 and renamed *Living Lab LOW3 – Laboratory for sustainable architecture and lifestyle* at the ETSAV Campus at Sant Cugat del Vallès (Barcelona) with the objective of establishing an open platform for collaboration with companies, and an exploration of experience-based concepts for teaching, research and innovation activities.

Living Lab LOW3 adds since then value to the academic offer at UPC-Barcelona Tech through its innovative transdisciplinary educational programs, transmitting experience-based knowledge about integrated energy design in architecture and a holistic approach to sustainability. This paper argues that Architecture Living Labs like Living Lab LOW3 make a positive contribution to architectural education in its approach to sustainability including the holistic paradigm shift towards solar architecture, renewable energies and standards like Nearly Zero Energy Buildings.

3. Methodology

The concept of Living Lab LOW3 is influenced by the concept of user involvement in research and innovation, derived from the definition of Living Labs, as well as the co-creation and open innovation in real-life settings through a multi stakeholder approach (academia, companies and research entities but also local administration), understanding both students, researchers as well as citizens as the “users” of this newly generated platform. (Masseck 2013)

The concept of Living Lab LOW3 is that of an activities platform with a participatory approach to teaching and learning based on a prototype solar house, offering its spaces, its equipment and its infrastructure to diverse user groups from both inside and outside the UPC.

Teaching and learning activities take place in parallel with research projects and outreach activities in order to create synergies between sectors, people and disciplines. Finally, Living Lab LOW3 is also a place for the networking of people in order to engage in new sustainability projects and initiatives, fostering the human factor behind these activities.

Living Lab LOW3 is an educational research project under continuous development since January 2011. During almost 5 years of its existence, new teaching formats, methods and tools have been tested regarding the link between formal and non-formal learning, the exploration of the personal learning environments of participants and the synergies between teaching, research and innovation.

Living Lab LOW3 applies a mixed-methods approach with quantitative and qualitative research methods. Phenomenological research has been used in the Live-at-LOW3 experiment, evaluating the experience of students living a sustainable lifestyle in the LOW3 solar house. The tools used are surveys, questionnaires, semi-structured interviews, amongst other formats like video documentaries and participant’s videos.

4. Results

Results of this innovative educational project can be described in the following areas:

- *General educational and research activities* referring to a huge amount of diverse activities regarding teaching and learning as well as research and innovation at an university campus
- *Specific Living Lab teaching formats* regarding innovative approaches to sustainability education applying a user-centered living lab approach, and
- *Activities as a higher education transition platform*, which contributes to a holistic sustainability transition of university and the society it is embedded.

4.1 Activities at Living Lab LOW3

Since 2011 3 regular Living Lab LOW3 courses, 6 innovation seminars, 2 international sustainability seminars, 1 house occupation experiment, 5 open doors days and around 25 educational visits have taken place at Living Lab LOW3, with links to different Master and PhD Programs both inside and outside the UPC and the ETSAV undergraduate program. Additionally more than 30 specific events opened up the house to user groups to disseminate knowledge to the academic community and beyond.

Fig.1 shows an educational activities map of the project, resumming the areas of knowledge; disciplinary, transdisciplinary and ESD related initiatives, as well as the corresponding formats, methods, and outcomes:

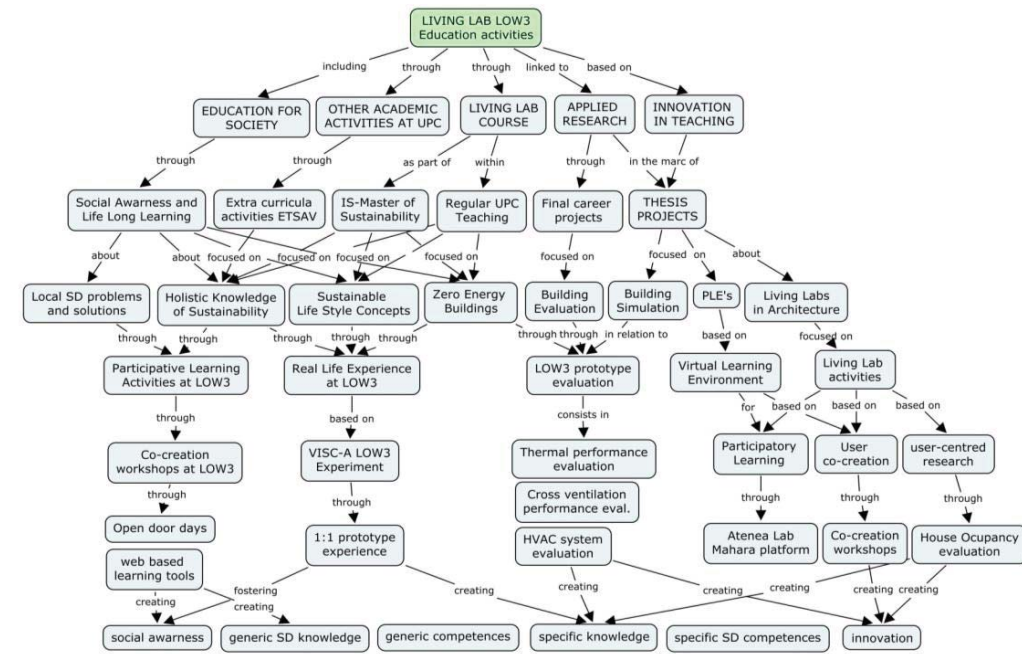


Fig. 1: Educational activities map Living Lab LOW3

4.2 Live-at-LOW3 Experiment

One of the most intensive, experience-based, transformative teaching and learning activities has been the 'Live-at-LOW3' experiment, a house occupation experiment in 2012.

The 'Live-at-LOW3' experiment was carried out within the elective course "Living Lab LOW3", linked to the Master Program Sustainability (IS.UPC) and the ETSAV undergraduate program.

This teaching and learning concept needed special commitment by the participating students. No regular timetable could be guaranteed during the course. The house-occupation experiment has been a holistic approach to user-centered research.

Two selected students evaluated and tested the prototype solar house during 14 days with the participating course students preparing, accompanying and evaluating the experiment through the monitoring and evaluation of the inhabitant's lifestyle with a holistic view on housing, consumption, food and mobility.

This course had a transformative effect on its participants, as in parallel to the generated theoretical knowledge about sustainable lifestyles, the related experience-based learning showed to be highly effective.

The experiment included:

- Monitoring energy consumption (daily consumption, relation to daily activities, comparison with solar production)
- Assessing water consumption (grey water recycling, dry toilet, water saving measures)
- Measuring waste production (daily production, type and weight)
- Assessing indoor comfort (day and night comfort in the house, privacy, air quality, noise)
- Reporting about food habits (local market, own vegetable garden and even 2 hens at the campus)
- Calculating the overall ecological footprint of the inhabitants

Results were published in course reports¹, the experiment was filmed and published through a documentary as well as local newspapers, and television showed interest in the experiment and its outcomes².

A holistic learning and user-centered research process was conducted in order to evaluate the LOW3 solar house, its concept, its technologies, and the resulting comfort for inhabitants. A wider engagement of the academic community, as well as society in general, could be achieved through open door days, media interest (national and local TV and radio emissions, digital newspapers) and the use of social networks and ICT (YouTube channel for video diary, documentary, live webcam).

The educational experiment was very successful, with students evaluating their participation and related learning as very positive. Nevertheless the educational format had to overcome administrative and legal issues, was time consuming for all participants, depending on a special personal commitment of all participants, and needed a certain amount of economic resources, which is the reason why this format could not be repeated since then.

4.3 The role of Living Lab LOW3 as multi-stakeholder platform

Living Lab LOW3 has shown to function as a multi-stakeholder platform for the following activities:

- Interchange between the professional and the academic world of architecture, bringing together professional associations interested in life-long learning and additional professional qualification programs, and the university (students, teachers, research groups), creating synergies between the academic and the professional world of architecture and building construction.
- Link to the productive sector of the building industry, allowing synergies in the knowledge dissemination about materials, products or services, within an environment which allows critical reflection, in-situ evaluation and as a consequence, a creative approach to innovations.
- Link to public administration, allowing collaboration between municipalities and academia regarding knowledge generation and dissemination, consultancy services, formative activities as well as specific project developments.

¹ http://www.low3.upc.edu/eng/plataforma_eng.html

² <http://www.livinglab-low3.blogspot.com.es/2012/10/fin-del-primer-experimento-visc-low3.html#more>

- Link to society, offering a place for knowledge dissemination and critical reflection, learning and experiencing different aspects related to a more sustainable lifestyle like the resource consumption in buildings, the environmental impact of materials, alternative forms of living such as co-housing, or the amount and impact of food and water consumption in private households.
- Transition Platform for the academic community, serving as a place for meeting, working and innovating for all kind of groups of the academic community (and beyond), generating synergies and allow the creation of new initiatives e.g. for HE transition projects towards SD, or community outreach projects, organized by student teams or even administrative staff. This approach reflects the idea of Living Labs as *Transition Arenas* e.g. for SD transition of HEIs. (Masseck 2016)

Figure 2 shows the diversity of uses of Living Lab LOW3 for research, teaching and outreach.



Fig. 2: Diversity of uses of Living Lab LOW3 for research, teaching and university outreach

Living Lab LOW3 today forms part of a new, emerging educational ecosystem at ETSAV, which links formal teaching with informal learning and established educational courses to a whole series of outreach initiatives supported by non-formal learning environments at the campus.

5. Conclusions

Architecture Living Labs can serve as multi-stakeholder platforms, which connect the academic world with its surrounding - the professional world of architecture and building construction, the productive sector, public administration, and last but not least, society as a whole. Through its experimental character, Living Labs can offer a place to meet, reflect, discuss, learn, explore and develop ideas, concepts and strategies with regard to sustainability in a most holistic way, not only limited to architecture but also considering the lifestyles adopted by society which include existing consumption and production models, political and economic issues, as well as social processes and innovations.

The diversity of activities related to one single platform like Living Lab LOW3, allowed the creation of many synergies among actors, programs and projects. Stakeholders have the opportunity to participate in a community of users beyond established academic structures, with transversality from high school students up to senior researchers.

In this sense Living Labs can be seen as social ecosystems within the specific context of university and with a strong link to the surrounding socio-economic context, fostering the creation of transversal educational communities.

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