Learning sustainable building by doing architectural detail models

First International Conference on Sustainable Energy Education (SEED 2024)

Book of proceedings

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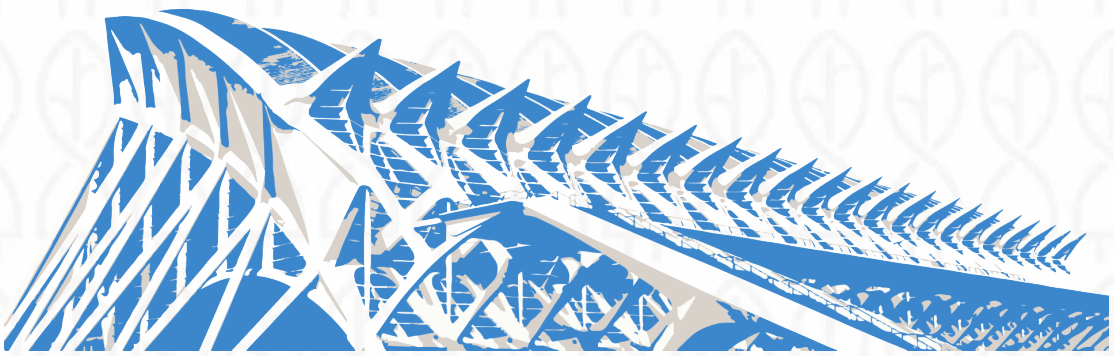

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Prologue

This volume contains the selected extended abstracts of the First International Conference on Sustainable Energy Education (SEED 2024) held in Valencia, Spain 3-5 July 2024.

In its first edition, the SEED conference has become the leading forum for lecturers of vocational training and higher education, researchers, policymakers, and practitioners to exchange ideas and experiences and tackle the challenges of the energy transition to facilitate well-equipped learners, students, professionals, and suitable labor capacity in an environment in which technologies constantly evolve.

During the conference, the partners have co-created and increased not only regional cooperation but also transnational cooperation. Good practices and innovative approaches for learning with impact have been exchanged in the form of oral and poster presentations and developed in the form of workshops.

The SEED conference was designed as the strategic tool for transnational learning and cooperation of the European-funded project CoVE SEED (Centre of Vocational Excellence – Sustainable Energy Education), focused on providing excellent and innovative education to become a fossil-free energy world.

SEED sees education as an important driver for innovation and growth, agile in adapting to the labor market. The objectives of the conference and ultimately the project are therefore focused on innovative energy education that meets the needs of the labor market: a) Preparing learners, students, and professionals with skills and competencies for the future; b) Empowering regional innovation based on regional needs; c) Upscaling and promote work-based education, and will lead to d) The establishment of an international learning community and e) establishment of Centres of Vocational Excellence (CoVES).

The CoVE SEED project consists of educational providers (EQF level 2-7), working professionals, and policymakers from Spain, The Netherlands, Greece, Germany, and Finland. The result is an international community dedicated to sustainable energy continuously growing by activities such as the SEED conference. and Funded by the European Union. Erasmus+, EU Solidarity Corps under grant agreement No 101056147.

The selection of the scientific program was co-directed by Dr. Elena de la Poza Plaza, Dr. Amparo Blázquez Soriano, Dr. Martijn Rietbergen, Ms. Mariola Guarinos, PhD candidate Evridiki Mantela, and Dr. Semih Severengiz, who led a team of 220 program committee members representing 33 countries in five continents.

Following the call for papers, the conference received 180 extended abstracts and 30 workshops from 35 different countries. At least two program committee members reviewed all the submitted extended abstracts under a double-blind review process. The proposal for workshops was also peer-reviewed by the scientific committee. Finally, 114 extended abstracts were accepted to be presented during the conference:

85 as oral presentations and 29 as posters. All of them are published by the UPV Press in this volume. In addition, 18 workshops were accepted to be hosted during the conference. The assessment and selection process ensures a high-quality program greatly valued by the research and practitioners' communities.

Considering both the origin of the participants and of the program committee members, 53 different countries in total are represented. This demonstrates the great international dimension of the event and how we succeeded in our strategy for transnational learning through the SEED conference.

SEED also featured four Keynote Speakers and one Honored Guest Speaker who overviewed important current topics: Prof. Francisco Beltrán from KTH Royal Institute of Technology in Sweden discussed *the Nordic approach to sustainable energy education*. Dr. Débora Domingo and Dr. Nuria Matarredona from Universitat Politècnica de València, Msc. Davide Roletto from Climology and Msc. Eugenio Domínguez Amarillo from Hybrid Energy Storage Solutions Ltd. discussed *Priorities for Sustainable Energy Education*. The session was moderated by SEED Honored Guest Speaker Prof. Dr. Edward. S. Rubin from Carnegie Mellon University.

The conference was hosted by the Faculty of Business Administration and Management of the Universitat Politècnica de València, ranked as the best technical university in Spain by the Academic Ranking of World Universities (ARWU) since 2018. Valencia is a city of culture and heritage. It is the third largest city in Spain, and its location on the shore of the Mediterranean Sea provides its citizens and visitors with privileged weather.

The organizing committee would like to thank our supporters and sponsors, especially Istobal who made this conference a great success. Also, thanks are indebted to the invited speakers, authors, program committee members, reviewers, session chairs, presenters, supporters, and all the attendees.

Our final words of gratitude must go to the Faculty of Business Administration and Management of the Universitat Politècnica de València for supporting and making it possible to become a great event.

Elena de la Poza Plaza
Amparo Blázquez Soriano
Ruijing Wang
Annamaria Sereni

Scientific Editors

List of workshops

1. **Enabling the flow of knowledge for the Energy and Hydrogen Transition**
   Chairs: Marsha Wagner, Jan Geurt van Kessel, Pim Opraus and Yvette Lanting
   Organizations: Energy Innovation NL, GroenvermogenNL, HAN University of Applied Sciences

2. **Sustainable Energy Education: Delivering the energy workforce of the future**
   Chairs: Mascha Moorlach and Jacqueline Garcia
   Organization: Transforming Energy Access – Learning Partnership (TEA LP)

3. **ESExNBS@NEB - Exploring Sustainable Education implementing the Nature-Based Solution in the New European Bauhaus perspective**
   Chairs: Elena Mussinelli and Ellie Mavroudi
   Organizations: ENVI-Reg Observatory (Politecnico di Milano) & Cluster of Bioeconomy and Environment of Western Macedonia (CluBE)

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   Chairs: Karolien Van Riel and Rob De With
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5. **Game-based Learning for Sustainability in Management Education (GAME-SME)**
   Chairs: Fabio Nonino, Luca Fraccascia and Mirko Giagnorio
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6. **Empowering Through Education: T-Shore's Approach to Wind Turbine Technician Training (T-shoreEdu)**
   Chair: Gerben Huiszoon
   Organization: The T-shore Project partners

7. **Build your own LEAF: Learning Ecosystem Taking Action for the Future**
   Chairs: Linette Bossen and Saskia Postema
   Organization: Delft University of Technology

8. **Sustainable Business Models in practice: a business game competition (BG-COMP)**
   Chairs: Fabio Nonino, Luca Fraccascia and Mirko Giagnorio
   Organization: Sapienza University of Rome

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   Chair and organization: JUST GREEN AFRH2ICA consortium

10. **Unveiling Training and Skill Requirements for Driving the Adoption of Emerging Technologies in the Renewable Energy field - RE-SKILLS Workshop**
    Chair and organization: LOMARTOV

11. **Attract and train European technicians in Energy Transition**
    Chairs: Gregorio Blanco Sáez and Anabelle Moriceau
    Organizations: Centro de Formación Profesional XABEC & Smart Energy Systems Campus

12. **Transforming Sustainable Energy Education (TranSEED)**
    Chairs: Jan Lauwerijssen, Carme Huguet, Fernando Pascual Fuentes and Julian Mateo Muñoz
    Organizations: The Netherlands ROC Midden Nederland, The Netherlands Environmental Science and Sustainability group, IE University, School of Science and Technology, IE University, Spain GVA & IES Alto Palancia, Segorbe (Castellón) – CFSRE Higher Cycle of Renewable Energies.

13. **Applied and Innovative Research within VET Education for the Energy transition**
    Chairs: Barbara van Ginneken, Prof. Dr. Henning Klaffke, Dirk de Wit and Miriam Korstanje
    Organizations: The project partners of the AIRinVET project (ISSO, BHH, Katapult network and CoP of the Erasmus+ CoVE)

14. **H2 VIRTUAL TRAINING**
    Chairs: Dr. Michel Galaup, Dr. Maria Gonzalez Martinez, Pr. Pierre Lagarrigue, Dr. Valérie Lavergne Boudier and Dr. David Panzoli
    Organization: Institut National Universitaire Champollion

15. **Facilitating upliftings in solar energy storage (FUSES)**
    Chairs: Úrsula Pérez Ramírez
    Organization: Ampere Energy

16. **Challenges of International Master Degree Courses in Renewable Energy Systems**
    Chairs: Andreas Wolf
    Organization: Vela Solaris AG (Winterthur, Switzerland)

17. **Explore integration of sustainability in education from a reflexive, SDG and entrepreneurship perspective**
    Chairs: Lenny van Onselen and Sofia Pouri
    Organizations: HU University of Applied Sciences & CLuBE

18. **Accelerate matchmaking in a network: what can we learn from trees and computers?**
    Chairs: Frans van den Akker and Eugene Zaaijer
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Track 4: Sustainable Education

Learning sustainable building *by doing* architectural detail models

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Abstract

The paper presents the outcomes of an experimental didactic activity aimed at developing three-dimensional architectural details models starting from the exploration of "zero cost" materials and products. This activity was proposed to students in the first year of the degree course in Architecture at Politecnico di Torino, as part of the course Culture and Fundamentals of Architectural Technology.

By considering the building as the set of spatial and technical elements characterised by their function and relationships, the process of architectural detail modelmaking allows students to understand the functional roles of the different building components, and to explore how different elements and materials integrate to realize a sustainable and energy-efficient building.

Furthermore, the choice of using waste or recycled materials has brought the students closer to sustainability issues, in particular focusing on material recovery and the circular economy. The students creatively explored the 'zero-cost' materials available to them, selecting those that visually or tactically alligned with the characteristics of the architectural element they intend to model.

The models were collected in a book. The result is an unusual open access catalogue of architectural details easy to understand, made by architecture students for architecture students.

Keywords: architectural technology; technical element models; sustainable building; learning by doing.

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1. Introduction: hands-on activity and modelmaking as learning tool

In this increasingly digitized world, physical models still play a strategic role in teaching architectural design and architectural technology. There are several benefits: from providing a tactile and interactive experience that helps the creative process flow, to contributing a better understanding of scale and proportion, and enabling exploration of a building's structural systems, components and material.

In several national and international schools of architecture, the hands-on activity of physical prototyping is a well-established and widely practised activity, and the learning-by-doing approach is considered a distinctive element in the teaching process (Paris, 2017).

A learning by doing approach has been adopted for several years by the Architecture Technology research group of the Politecnico di Torino. In collaboration with the Laboratory of Innovative Technological Systems (LaSTIn), the research group conducts many experiences where the development of prototypes plays a key role, intended both as a learning tool and as a research and experimentation tool (Fasano et al., 2023).

However, students generally develop their technology model at the end of their course of study, or even at the time of the dissertation if this is of an experimental nature and uses prototyping as a research tool. Instead, the paper describes an experience that aimed to explore the possibility of introducing architectural modelmaking in the first year as a real learning tool (Eppinger and Ulrich, 2012) (Mayuk and Coşgun, 2020).

Students thus had the opportunity to use the model not only to represent compositional and typological choices, but as a tool to study in an experimental way the features of materials, components and construction systems and their interrelation in the building system. The aim is to train the skills and competences needed to identify the criteria for choosing between alternative technical options during the design phase of a sustainable building, according to a Hands-on Learning Experience approach (Yildirim et al.,2014; Pak and De Smet, 2022).

2. How to build models: an experiential working methodology

The didactic experimental activity aimed at developing three-dimensional models of architectural details is part of the activities we carried out within the Culture and Fundamentals of Architectural Technology course in the first year of the Architecture degree program at Politecnico di Torino. The course intends to provide students with an initial framework of theories, methods and tools useful for understanding and learning how a sustainable building is made.

The course includes lectures on architectural technology, meetings, seminars and practical activities. Meetings and seminars make it possible to collect direct testimonies from designers, companies and experts in the construction sector enabling deeper exploration of

specific topics by gaining knowledge, skills and experiences. Practical activities, such as visits (virtual and physical) to materials libraries, construction sites and companies, help students to understand material, technological and performance features of building elements, as well as how materials and building components are connected, combining theoretical study with the observation of objects and their manipulation. A series of exercises on the analysis, comprehension and graphical representation of technological systems completes the training course.

In this context, modelmaking of technological details fits in. The idea of assigning this type of exercise, linked to the concepts of learning by doing, arase during at the special moment of the pandemic - when teaching was conducted exclusively remotely - to provide students with the opportunity to engage in a hands-on activity. Working with waste materials, using what you have 'at hand' without the need to buy specific materials, had the advantage of placing all students in the same conditions. Furthermore, the choice to use waste or recycled materials brought students closer to sustainability issues, in particurarly concerning material recovery and the circular economy. Packaging, textile waste, household items, food packaging are materials that are available and accessible to everyone, and can be processed with low-tech technologies that we all have, such as glue, tape, scissors.

The students were asked: to identify a technical element of the building envelope; to creatively explore 'zero-cost' materials available to them, selecting those that visually or tactically aligned with the characteristics of the element to be modelled; to develop a three-dimensional model, on a proportional scale, highlighting materials and components.

Different approaches were employed to develop models, resulting in a wide variety of solutions: all-round, embossed, single-material or prevalent material models, of different sizes. Some students paid particular attention to packaging, graphic composition and model presentation. The exercise was developed individually and independently. During the final exam, the model presentation facilitated discussion on sustainability issues and validated understanding of the functional roles of the different materials and components that characterize the building system and the principles of energy efficiency.

3. Architectural detail models

Each student chose the detail to model from those discussed during theory lessons and graphically explored in previous drawing exercises.

These are the main technical elements of the building envelope that detrmine thermal exchanges with the surrounding environment and therefore the energy efficiency:

– Foundation Systems, in particular ground floor with ventilated cavities;

– various alternatives of the Wall Systems (brick wall, dry-built wall, e.g.) and their connections with the Floor Systems;
– Roof Systems with the different technical solutions of flat, green or pitched roofs.

The models were catalogued specifying for each one: the technological system and elements, the different functional layers represented, the size and the list of 'zero cost' materials used.

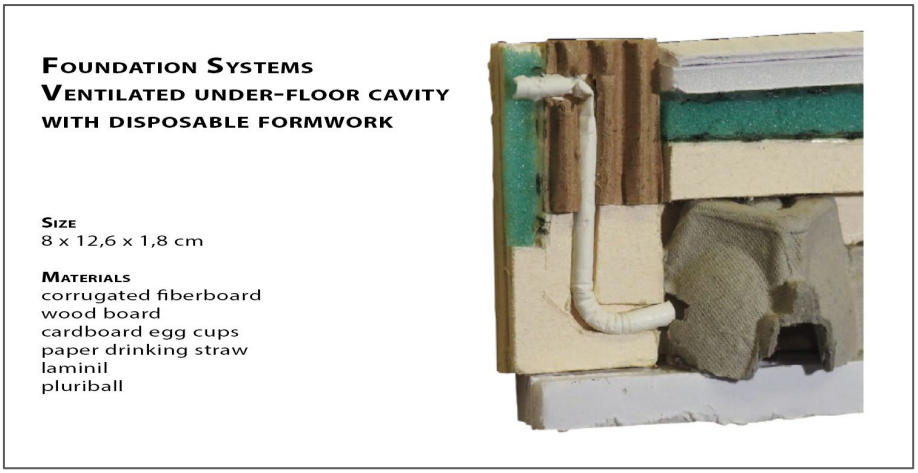
Some of the most commonly used materials were: packaging materials, such as cardboard, bubble wrap, polyethylene sheets; scraps from other modelling activities, such as Laminil or vegetable cardboard cuttings; materials and objects commonly found at home, such as different types of sponges, coffee capsules, gauze, surgical masks, caps, cloth.

These waste materials took on different functions within the various models, depending on the different material interpretations given by the students. For example, dish sponges represented insulation material well, but when appropriately coloured, they also became the substrate of a green roof; egg cups were used as formwork for the ventilated crawl space in the ground floor, but also as a draining layer of the green roof.

3.1 Foundation Systems

The Foundation Systems section encompasses a variety of technological solutions related to the building's connection to the ground. The most frequently represented solution is the ground floor with a ventilated crawl space with disposable formwork. Egg cups, plastic bottle bottoms and biscuit containers were useful waste materials used to represent disposable polypropylene formwork; paper and plastic straws, along with various types of tubes, well represented ventilation pipes for the ventilation of the crawl space; foam rubber and corrugated cardboard were assimilated as insulation materials.

Fig. 1 – Foundation System Model (Card n. 002 - Open Access Catalogue)



Source: Lacirignola and Montacchini, 2023

3.2 Wall Systems and Floor Systems

The models in this section represent different technological alternatives of external walls and intersection details between the wall systems and floor systems.

Different types of walls were explored: brick walls with external, internal or cavity insulation, x-lam panel walls, wood-framed systems, ventilated facades; combined with traditional brick slab solutions or more innovative steel or x-lam solutions.

Hydrophilic cotton, dish sponges, Plumbers Hemp, all represent insulation materials with different characteristics and density; corrugated cardboard was largely used to represent brick blocks; toothpicks, wooden ice-cream sticks, wire were used as support structures for ventilated facade cladding.

Moreover, in floors, nails and steel wire represented the rebar and various types of tubes were used for the pipes of the underfloor heating system.

Fig. 2 – Wall and Floor System Model (Card n. 36 - Open Access Catalogue)

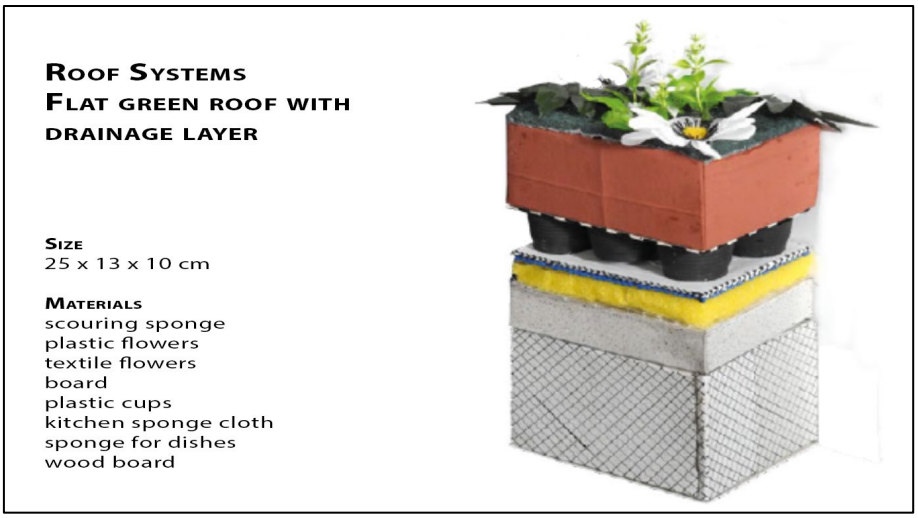
Source: Lacirignola and Montacchini, 2023

3.3 Roof systems

In the Roof Systems section, the green roof system was the favourite among the students.

For green roofs, students crafted the vegetation layer using dry leaves, stabilised moss, fabric, plastic or paper flowers and leaves. Dish sponges were a useful material for representing the different layers of the green roof technology package; sponges with an abrasive side were used to create the substrate and vegetation with a single material; egg cups, pill blisters, coffee capsules represented the drainage layer; surgical masks rapresented the filtration layer.

Fig.3 – Roof System Model (Card n. 79 - Open Access Catalogue)

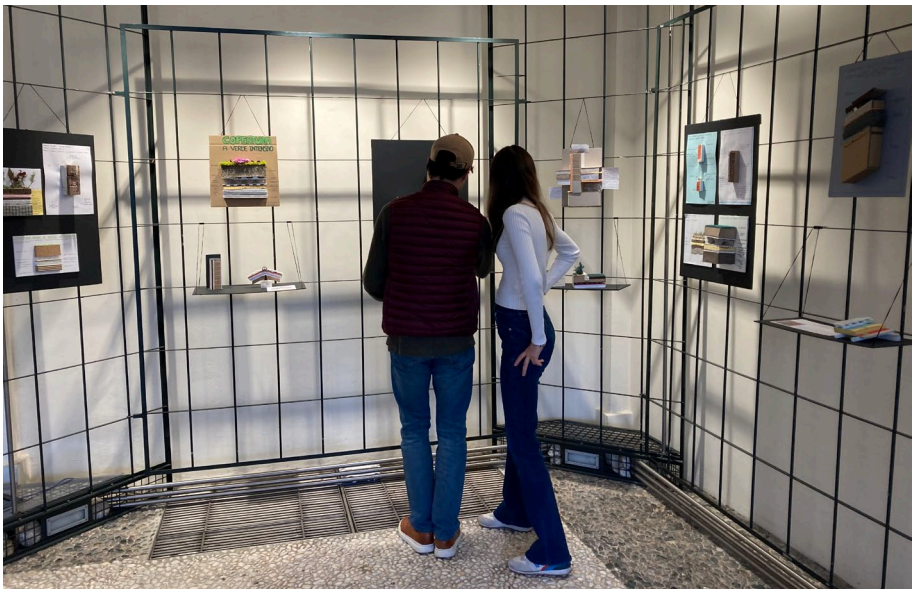


Source: Lacirignola and Montacchini, 2023

4. Results and Conclusion

An exhibition was the first opportunity to present three-dimensional models of architectural details at the School of Architecture. Like the models, the exhibition itself was built at 'zero cost' using recycled materials and waste from previous installations.

Fig.4 – Detail models exhibition



Source: Own elaboration

Then, the presentation of the models in the form of an open-access catalogue [Lacirignola and Montacchini, 2023], made them available as a tool for studying and exploring the

technical elements of the building and highlighted how it is possible to use waste or recycled materials to make models and understand their function.

The catalogue is annualy expanded with new models and holds an educational and training value for students. Within it they find the suggestion to adopt a working methodology based on the synergetic use of several forms of representation to understand objects and on hands-on experimentation to reinforce theoretical knowledge. Furthermore, it offers a collection that becomes a working tool for understanding the functional roles, layers and components that characterise the main parts of an energy-efficient building.

Thanks to its simple and accessible language, the catalogue serves not only as a learning tool, but also as an informative resource for anyone who wants to approach architectural technology and 'understand' how a building is made.

The experimental didactic activity described in the article, which refers to the learning-by-doing approach associated with the principles of the circular economy, proved useful and interesting and engaged students in understanding the fundamentals of architectural technology in a funny way.

This experience represents a step forward in architecture schools, where this approach is not so obvious and widespread and where students generally do not find many opportunities in the educational curriculum to challenge with in-field learning.

Overall, this is a methodology that can be replicated in other contexts, not only in architecture schools and not only in higher education, because it is able to combine learning, practical approach and even a little creativity. A way to bring the younger generation closer to the themes of circular economy and sustainability.

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Conflicts of interest

The authors declare that they have no known competing financial interests or personal relationships that could have influenced the work reported in this paper.

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