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Original
From Disassembly to Re-Assembly An Innovative Pedagogical Approach to Architectural Design and Upcycling Practices / Gasparotto, J., Ramirez, F., Fasano, C.. - ELETTRONICO. - (2025), pp. 1074-1081. (11th International Conference on Higher Education Advances, HEAd 2025 Universitat Politecnica de Valencia, esp 17-20 June 2025) [10.4995/HEAd25.2025.20080].

Availability:
This version is available at: 11583/3004830 since: 2025-11-05T09:44:49Z

Publisher:
Universidad Politecnica de Valencia

Published
DOI:10.4995/HEAd25.2025.20080

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26 November 2026

11th International Conference on Higher Education Advances (HEAd'25)
Universitat Politècnica de València, València, 2025
DOI: https://doi.org/10.4995/HEAd25.2025.20080

From Disassembly to Re-Assembly: An Innovative Pedagogical Approach to Architectural Design and Upcycling Practices

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How to cite: Gasparotto, J.; Ramirez G., F. A.; Fasano, C. (2025). From Disassembly to Re-Assembly: An Innovative Pedagogical Approach to Architectural Design and Upcycling Practices. In: 11th International Conference on Higher Education Advances (HEAd'25). Valencia, 17-20 June 2025. https://doi.org/10.4995/HEAd25.2025.20080

Abstract

In the context of new curricula methodologies, experiential learning and theoretical skills are being blended to tackle real case scenarios. As a result, methodologies such as the research-by-design approach are gaining momentum for their student-centred and dialogic approaches, highlighting a required change of perspective both on the teaching and learning spheres. In this regard, the following paper discusses the potential of this approach in the architectural technology teaching practices dealing with new challenges such as upcycling, where the canonical schemes may not be applicable. Therefore, the research-by-design approach has been tested as the working method in the "UP+IT – How to Disassemble a Building?" workshop, in which professors, researchers and PhD students from four Italian universities worked together to study and propose upcycling strategies for a real case scenario.

Keywords: *Research-by-design; experiential learning; teaching methodologies; architectural technology; upcycling.*

1. Introduction

In recent years, new innovative teaching and learning methodologies have been introduced and implemented within some of the curricula of universities, in the quest of diverging from the traditional frontal lectures (Shah et al., 2024). In unidirectional teaching, knowledge is transferred from teacher to students without considering a hands-on application of the presented concepts, promoting a passive learning approach. On the contrary, methodologies and tools such as the use of Virtual reality (VR) (Lu, 2022), Learning-by-doing approaches, Gamification (Mehelmy; Zeini, 2024), etc. are based on alternative educative environments, student-centered and dialogic approaches (Pak & De Smet, 2023) in which the experiential learning is achieved by applying the theoretical skills gained within lectures, into real case scenarios where one or

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more of the components (context, actors and actions) of the dynamic system of learning, are modified, expanding the impact on the students' thought process (Mackintosh, 2014). This approach is well suited to the architectural field, since design research needs a variety of expertise, including art, cultural studies, anthropology, cognitive psychology, and communication (Koskinen et al., 2013). The MIT (USA) is a representative case, that has already adopted the learning-by-doing approach by introducing hands-on activities in their study programs (Paris, 2017).

The research-by-design approach, based on a continuously interactive setting, can be integrated into the curricula of Architectural schools. This approach expects participants of the design process to creatively exchange, collaborate and develop new knowledge together (Roggema, 2016). This stimulus allows students to increase their critical thinking, problem solving and decision-making processes (Giordano et al, 2019). Fundamental to these learnings is the "failure" aspect, as it is core to the learning and reflective cycles, aimed at being experienced through hands-on learning (Djabarouti, O'Flaherty, 2019). In particular, research-by-design is a suitable, yet necessary approach to face the so-called wicked problems: problems with no final solution, which need to be continuously treated and directed, with a counterintuitive thinking and the development of new knowledge (Roggema, 2016). It is in this context that the workshop[1] *"UP+IT – How to Disassemble a Building?"* took place adopting the research-by-design approach, to address the complex theme of upcycling.

2. Design workshop: systematization and collaborative design

The workshop hosted several research groups from four different Italian universities: Politecnico di Torino; La Sapienza Università di Roma; Tor Vergata Università degli Studi di Roma and Politecnico di Milano and aimed at conducting research with a team of varying competencies, approaches, and perspectives. The research methodology was based on a practical work under the theme of upcycling applied to a specific case study that is part of Italy's modern history.

2.1. Upcycling applied to a Heritage Case Study

Upcycling in architecture is an emerging concept, able to be applied to the challenges listed by the European Community's Green Deal in order to limit the negative environmental impacts due to the construction sector. The upcycling concept requires a change of perspective in both the

[1] The workshop has been promoted as part of the research project *"Upcycling Architecture in Italy. Forging and Promoting a Renewed Building Culture"* project – founded by European Union - Next Generation EU within the PRIN 2022 PNRR program (D.D.1409 del 14/09/2022 Ministero dell'Università e della Ricerca)

teaching and learning sides, this involves applying strategies, such as design for disassembly, to deal with objective limits, in terms of the performance, that reused building materials and components may have in their "second life".

Through a particular Italian case study rooted in architectural history, the discussion seeks to address the preservation of heritage identity through disassembled components, adding layers of complexity and innovation in the current upcycling debate. The case study examined was the Istituto Tecnico Industriale Statale (ITIS) Volta in Tivoli (Rome, Italy). This building, designed in the 1960s by the BDS team under the direction of architect Pietro Barucci, stands as an example of industrialized architecture from the mid-20th century. It is distinguished by a modular and dismantlable construction system, patented to integrate the use of lightweight prefabricated panels with innovative metallic joints. Therefore, it served as a significant case study thanks to two key features: the disassemblability of its structural components and the availability of extensive technical archival documentation. These two aspects provided an ideal basis for in-depth exploration of the construction process and for investigating the potential of architectural upcycling.

2.2. A multidisciplinary approach: combined expertise and teamwork

To address a complex topic such as the relationship between architectural heritage and the upcycling approach, a heterogeneous working group, both in terms of professional expertise, as well as hierarchical levels, was established. Professors, researchers and PhD students from various fields of architecture (Architectural and Urban Design, History of Architecture, and Technological and Environmental Design of Architecture) and engineering (Technical Architecture and Project Evaluation) closely collaborated during an intensive research workshop held in June 2024 at La Sapienza Università di Roma.

The workshop was organized into three groups, each engaged in the development of a distinct macro-theme while maintaining flexibility and interchangeability across tasks. In order to ensure that every member of the group contributed their expertise, each team was supervised and supported by at least one professor.

Moreover, specific roles with unique functions were identified during the workshop: *Scientific explorers, Highly qualified researchers* and *Facilitators*. *Scientific explorers* focused on studying and analysing basic statements of the case study, essential elements for constructing a comprehensive informational framework, both technical and theoretical. *Highly qualified researchers,* who led and coordinated activities within the macro-groups, providing specialized guidance on specific areas such as Building Information Modelling (BIM), structural considerations and economic and financial evaluation. Finally, *Facilitators* managed real-time communication between macro-groups, promoting systematic exchanges of information, ideas, and knowledge.

This collaborative and peer-to-peer interaction fostered a dynamic synergy among participants, leading to the development of a complex operational model based on interdisciplinary cooperation. Within this cooperation, each member's participation was fundamental for the research success, therefore, as a method to confirm the participants' contribution, daily discussions were held to share the work progress and the challenges faced.

3. Research framework

The workshop has been divided into three phases: *Individual research, Research-by-design* and *Systematization of the results*. A noteworthy aspect of the process was the collaborative methodology adopted: each member of the group contributed their expertise, resulting in a mature and coherent outcome that synthesized the diverse inputs (Fig.1). In this context, the synergistic collaboration between professors and students fostered a productive dialogue.

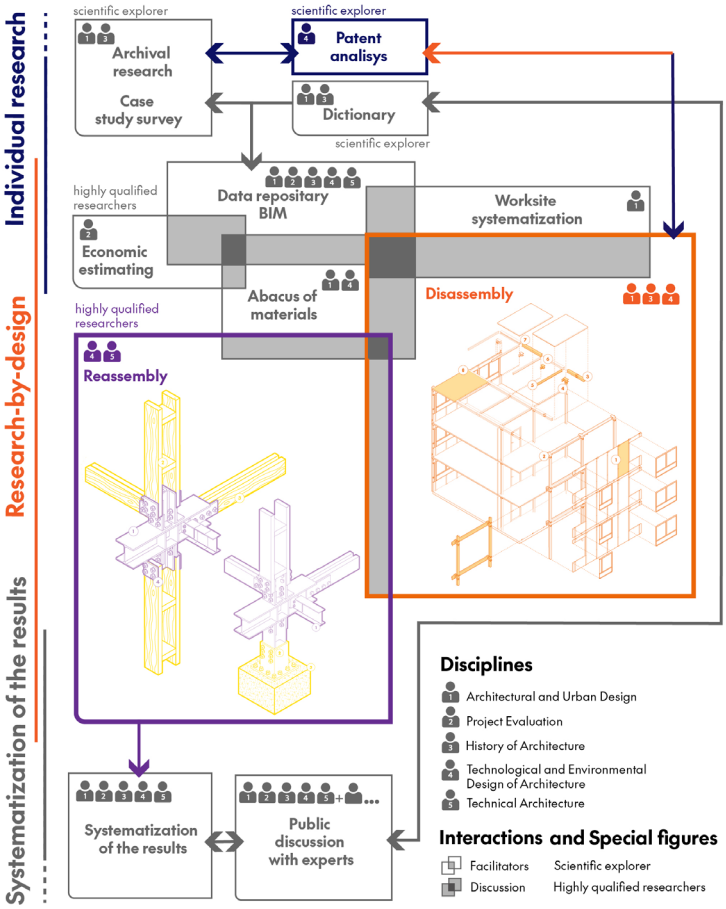


Figure 1. Methodological concept.

3.1. Individual research

In the first phase, a series of theoretical online lectures were held within the previous month to the workshop, during which, a group of experts presented a range of case studies on upcycling. Additionally, parallel to the lectures, the groups from each university were invited to explore specific aspects of the research:

- *Archival research.* Collection of original technical and historical documents of the ITIS Volta;
- *Dictionary development.* Critical synthesis of recent literature to provide a shared framework on keywords such as Upcycling, Recycling, Downcycling, Reuse and Superuse;
- *Survey and BIM modelling.* Development of a digital 3D model based on archival information and first on-site measurements as a base for the following working steps;
- *Architectural technology analysis.* Study of the patent and original technical drawings by Architect Barucci in order to gain a deeper knowledge of the case study and to understand the implemented technology of the building and sparked the first ideas of possible disassembly processes.

3.2. Research-by-design

Following the initial phase of analysis, an on-site investigation was essential for gaining a deeper understanding of the case study. During the site visit it was possible to examine the architectural elements and stratigraphy components that currently characterize the building and to observe how these differed, either partially or entirely, from those represented in the archival documentation. This discrepancy might be since, over the years, the school has undergone multiple maintenance operations, replacements and structural reinforcements.

Therefore, it became necessary to question the previous analysis and explore new intervention hypotheses. This process was both highly engaging and challenging, as it required the integration of diverse tools, including historical documentation, laser-scanner, survey data and the BIM model, to conduct an “in reverse” analysis. Specifically, in order to determine how to disassemble the building, it was essential to identify the most recently installed component and work backward to dismantle the various elements systematically. During this phase, efforts were made not only to preserve the largest possible quantity of materials, but also to pay particular attention to the building's defining features, such as the specific joints patented by Barucci. Significant discussion was undertaken among the participants to determine how to preserve their historical value even in the event of complete disassembly.

Additionally, graphical outputs such as diagrams, charts and exploded axonometric drawings were produced to better visualize the disassembly phases and identify components that could be

reused in subsequent stages. Particular focus was placed on the modular façade panels, floors and steel structural elements. These components were subsequently cataloged, enabling potential reuse in the development of new projects.

As the final stage, the working group focused on analyzing possible reassembly strategies aimed at defining examples of design prefiguration. This phase, characterized by a more creative approach, highlighted the diversity of perspectives within the group, fostering a constructive debate on potential spatial configurations and the appropriate scale of intervention. To explore the compatibility between the most significant components, an analytical tool in the form of a matrix was employed. This matrix, designed to systematize the various elements, facilitated the selection of the most emblematic components and allowed the identification of three hypothetical reassembly configurations. Additionally, the matrix played a crucial role in implementing the principle of upcycling, enhancing the value of existing materials and expanding their design potential. The three prefigurations provide specific design guidelines at a detailed scale, defining how to reassemble the elements and integrate them with new materials.

3.3. Systematization of the results

The results obtained during the two previously described phases were systematized into a dossier[2]. The workshop ended with a final discussion, that allowed the students to assimilate the main topics addressed during the research and to interrogate themselves on the questions still to be answered.

Furthermore, during the international conference *"Upcycling and Architecture in Europe. Towards a New Building Culture"* held at the Politecnico di Milano from September 20th to 21st of 2024, the workshop participants had the opportunity to present their findings and engage in discussions with esteemed experts in the field. This stimulating debate promoted the opportunity to confront multiple perspectives on upcycling, in order to consider the results achieved not as an endpoint, but as ongoing research.

4. Conclusions and future perspective

The workshop *"UP+IT – How to Disassemble a Building?"* has demonstrated the potential of research-by-design methodologies in addressing complex themes, such as the architectural upcycling in heritage preservation. By combining targeted seminars, theoretical research and hands-on activities, the project fostered a collaborative and interdisciplinary environment that not only advanced the study of upcycling from the existing building stock but also provided an

[2] Bologna. A., Garcia-Fuentes. J., Giannetti. I., Neri. G., Germanò. R., (2024). Upcycling Architecture in Italy. Design Workshop Results. https://www.upcyclingarchitecture.it/items/up-it-design-workshop-results-booklet

innovative framework for architectural education. The inclusion of experts and participants from various fields of architecture and engineering facilitated a rich exchange of ideas. Moreover, the interaction between professors, researchers and students proved to be a powerful tool for promoting critical thinking and creativity while advancing knowledge in the field.

This approach is characterized by its dynamic and interactive nature, lacking a defined beginning or endpoint. Instead, it evolves continuously and remains open to critical reassessment. Rather than producing definitive results, it generates opportunities for continuous reflections and dialogues.

In conclusion, the implementation of the research-by-design method, based on the dissolution of disciplinary boundaries, can represent a suitable tool for working groups that include inexperienced individuals or beginners. It is evidenced, that a possible limitation or strength of this approach is the challenge to quantify the individual contributions of each participant, consequently, in order to obtain high quality results, it is important that the involved students display a willingness to tackle the research topic.

Such approach enhances participants' skills and supports the development of research principles and methods while guiding them in navigating the research environment. By fostering engagement, this methodology transforms participants from passive recipients of knowledge into active and proactive contributors.

Acknowledgements

We thank the research group of the *"Upcycling Architecture in Italy. Forging and Promoting a Renewed Building Culture"* project, for their invitation to participate in the *"UP+IT – How to Disassemble a Building?" w*orkshop.

This publication is part of the project PNRR-NGEU which has received funding from the MUR – DM 118/2023.



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