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Regenerative Design of Archaeological Sites: A Pedagogical Approach to Boost Environmental Sustainability and Social Engagement

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Abstract: Sustainable pedagogical approaches and practices have changed during the years, generating a set of philosophical, theoretical, and scientific concepts. Inside them, regenerative design is a proactive method based on systemic frameworks and developmental processes for maintaining the integrity of natural ecosystems, also enhancing human life, environmental awareness, social equity, and economic sustainability through the support of codesign techniques. This approach is widely used in architectural design, both for existing and heritage buildings, to address negative impacts of global warming, climate change, urban sprawl, touristic pressure, and other contemporary challenging phenomena. Specific workflows for archaeological sites have been never proposed, despite the fact that these sites face problems and risks completely different from other cultural heritage settings (e.g., physical development, pollution, tourism pressure, vandalism, looting, inappropriate excavations or interventions, lack of maintenance, funding, and legislation). This study presents a multicriteria decision analysis workflow for preserving and regenerating archaeological sites in a sustainable way through a deep understanding of current problems, values, features, and risks at urban and building levels. This method is tested with a pedagogical experiment at the UNESCO Site of Castersеprio (Italy), to investigate the interaction between heritage, environmental, social, and economic dynamics as well as to define its feasibility, applicability, limitations, and opportunities for further developments. The didactic process is supported by a participatory program among the key players of the site (owners, heritage and public authorities, and local associations), to create strong public support and a shared vision of the sustainable regeneration of the area. Differences between traditional and regenerative design processes, key design principles, shared criteria, replicability, novelty, and limitations of the pedagogic approach are also identified. Key findings of the present study are: (i) students need clear and shared design workflows for supporting their design projects; (ii) "*regenerative design*" involves multilevel dynamic training methodologies that motivate and involve the student while also improving their consciousness; (iii) the cooperation and the involvement of the stakeholders is important to favor a human-centered approach based also on social and economic interactions; (iv) digital technologies are fundamental for quantifying the key performance indicators in each design stage; (v) "*regenerative design*" boosts long-term planning and financial self-sustainability of the intervention; and (vi) multicultural design teams producing more innovative design ideas.

Keywords: regenerative design; multicriteria decision analysis; sustainable development; sustainable development goals; expansive learning

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1. Introduction

Sustainable development at the European (EU) level is supported through different policies at urban and building levels. Urban strategies boost energy transitions, carbon neutrality, affordable and clean energy, reduction of greenhouse gas emissions, biodiversity, climate mitigation, and adaptation [1–3]. Similarly, building actions focus on energy efficiency, renovation, and decarbonization [4–8]. This legislative framework underlines the importance of heritage conservation for safeguarding, enhancing, and transmitting the memory of a community for present and future generations [9–11]. Cultural heritage is considered a key component in several EU conventions dedicated to sustainable development [11,12]. The United Nation Educational, Scientific and Cultural Organization (UNESCO) considers culture as important as human rights, equality, and sustainability [13]. The EU "*Green Deal*" [1] and the United Nations (UN) [14] highlight its role for favoring resilience, climate adaptation, safety, and sustainability [14]. Moreover, the "*Paris Climate Agreement*" recognizes the positive contribution of traditional building techniques for climate adaptation [2], thanks to the use of natural sources [15,16], local, raw, and durable materials [16,17] that require low energy for production, transportation, and recycling. Furthermore, cultural heritage should be subject to special protection in spatial planning: generally, the monument is preserved, but its surroundings support the historical value and the functioning of the object. Thus, their protection is fundamental for preserving the natural and heritage values [18].

Sustainable development is divided in two streams: "*technological sustainability*" based on technical and engineering aspects, and "*ecological sustainability*" based on ecology and living systems principles [19]. According to these two approaches, sustainable practices and didactics have changed over the years, generating a set of philosophical, theoretical, and scientific concepts [20–31]. Each approach has specific definitions, principles, and criteria. First, the "*biomimetic approach*" looks to nature as inspiration for designing products and processes [25,26]. Biomimetic technologies derive from natural models at nano and macro scales, considering their self-evolution for solving engineering problems with tolerance, resistance, and resilience [25]. Similarly, "*biophilia*" creates a literal or evocative connection between nature and the human-made context to positively influence living systems, personal fulfillments, and processes [20,22]. Biophilic design is used both at urban and building levels, suggesting the following principles: (i) direct connection with nature and environmental features; (ii) inspiration from biomorphic forms and patterns; (iii) presence of water; (iv) dynamic and diffuse light and huge spaces; (v) thermal and airflow variability; (vi) presence of nonrhythmic sensory stimuli and rich sensory information; and (v) place-based relationships. Then, "*sustainable design*" is characterized by a neutral environmental impact. Their key principles are widely diffuse in urban planning and architectural practices, such as (just to cite some common concepts) [32]: (i) site potential optimization; (ii) minimization of nonrenewable energies; (iii) use of environmentally friendly materials and low environmental impact products; (iv) protection and conservation of water, energy, and materials; (v) enhancement of indoor and outdoor environmental quality; and (vi) optimization of operational and management practices. More recently, this approach has shifted into "*restorative design*" to reconnect people to nature thanks to the renovation of social and ecological systems [20,22,24,25]. Basilar principles concern the use of natural sources, renewable energy, and sustainable systems (optimization of natural light, energy systems, water, and materials) [22]. This approach is more integrated with the environment than the biomimetic one as it tries to optimize natural resources and patterns [25]. In addition, it is more active than "*biophilia*" as it evolves over time [25]. Otherwise, it ends when the system acquires the capacity to self-organize, assuming that it can be infinitely adapted to external modifications [25]. These ecologically based approaches try to stop degeneration processes and reduce their negative effects, focusing primarily on the initial environmental footprint [26]. More recently, the idea of "*regenerative design*" [25,27] was introduced as a "*living systems approach*" [27], to create a positive interaction between built, human, and natural systems for promoting restoration, renovation, and revitalization of the built environment [26,28]. It is a proactive approach based on systemic frameworks and developmental processes for maintaining the integrity of natural ecosystems, also enhancing human life, environmental awareness, social equity, and economic sustainability [20,25]. The "*regenerative design*" approach is based on a long-term prospective [29]. Fundamental principles are: (i) understanding places and their unique patterns (e.g., wind, water, energy, traffic flows); (ii) design for harmony with place; and (iii) co-evolution for the continuous adaptation of the project to external modifications. Inside this approach, the concept of "*regenerative heritage*" focuses on the protection and the revitalization of local history and knowledge [30,31]. This idea is different from "*restorative heritage*" that requires the adaptive reuse of heritage buildings through the improvement of their accessibility, flexibility, and functions' hybridization [31].

Regenerative design is widely used in urban planning and architectural design to reconnect people with the natural environment, addressing negative impacts related to global warming, climate change, urban sprawl, touristic pressure, and other contemporary challenging phenomena for environmental preservation, and human wellbeing. This approach is applied especially for the regeneration of existing cities and buildings. Inside them, various methodologies have been published for boosting the regeneration of herit-age buildings [33–35] and sites [36–38]. These methods consider both technical processes [33,35,35,38] and social needs [34,37,38] for favoring building resilience and retrofit. Re-generative design is used mainly to achieve environmental resilience in heritage building preservation and to reduce building damage from natural hazards, human habits, and climatic changes [33,36]. Furthermore, economic and social regeneration approaches are introduced to improve the livability and the touristic attraction of rural [34] or inhabited [37,38] heritage areas. Finally, regenerative design is applied to the energy retrofit of herit-age buildings, especially for reaching net-zero energy targets [35,35]. In addition, these workflows are supported by the use of innovative technologies [33,36] and codesign tech-niques [34,37,38]. Previous studies focus on traditional (or rural) and heritage (or listed) buildings as well as historical towns. These workflows and models cannot be applied to archaeological areas, as they face problems and risks completely different from other cul-tural heritage settings. Moreover, specific workflows for the regenerative design of archae-ological sites have been not realized.

Archaeological sites express human, social, and technical development through the embodied values associated with civil, historic, artistic, spiritual, symbolic, educational, natural, ecological, and economic practices. They are composed by tangible (e.g., history, structures, physical state, and constrains) [39–41] and intangible heritage (i.e., meanings, traditions, philosophies, representations, and rituals) [42,43]. Their preservation is faced with several risks connected to physical development, pollution, tourism pressure, vandalism, looting, inappropriate excavations or interventions, lack of maintenance, funding, and legislation [44–46]. Physical development has certainly had major impact on their disruptions and changes, as it is directly connected to settlement expansion and infrastructure growth [42] and is indirectly associated with pollution, mass tourism, and social engagement [10,46]. These aspects may also have a negative impact on the biodiversity of the area, not only on heritage resources [42]. Hence, their efficient conservation refers to social wellbeing, responsibility, people's engagement, and respectful economic growth [47]. Regenerative design can help them to face the effects of climate change, environmental and heritage despoliation, and land expansion in a resilient way. Thus, the main challenges for their revitalization refer not only to heritage (e.g., heritage preservation, enhancement, and management), but also to environmental (e.g., sustainable development, biodiversity preservation, use of resources, and improvement of local resources and systems), social (e.g., touristic attraction and people's engagement, wellbeing, training, and education), and economic (e.g., benefits, profits, and innovation) issues [42]. This embodies a robust interrelation within the three pillars of sustainability: environment, society, and economy [19]. The novelty of this research concerns the development of a specific workflow for the regenerative design of archaeological sites, considering their peculiarity, problems, and risks from a long-term perspective. Furthermore, its application to a pedagogical process at a higher education institution allows understanding of its feasibility, limitations, and opportunities for further development.

2. Aims

The study aims at defining a multicriteria decision analysis workflow for preserving and regenerating archaeological sites in a sustainable way through a deep understanding of current problems, values, features, and risks. This workflow is based on the multicriteria and transdisciplinary method to avoid resources' depredation; prevent heritage and environmental degradation; and create livable, safe, accessible, secure, and comfortable places [23,25]. To improve the effectiveness of the regenerative paradigm, this method has been tested at the architectural Design Studio of the Polytechnic of Milan for the regenerative design of the Italian World Heritage Site of Castelseprio. Design studios are creative learning spaces where students can cooperate, brainstorm, and learn by doing [48], and where students and teachers work together to find design solutions for real-life situations [49]. Based on this pedagogical approach, 54 international students worked in teams to solve the most important challenges in the area, presenting different regenerative design project ideas.

The key question at the basis of the work was: "*How can design regenerate an archaeological area with positive environmental, social, and economic impacts, also conserving original features, values, materials, and biodiversity through cleaner energy production?*" This goal is broken down into five subobjectives: (i) codification of shifts and differences between traditional and regenerative design processes; (ii) identification of a set of shared criteria to support designers and public and heritage authorities in the development and assessment of regenerative design plans; (iii) support for local decisionmakers through long-term planning, active contributions, and collaboration with the stakeholders; (iv) definition of limitations and opportunities for further development of the workflow through the application of a real case study; and (v) creation of a coherent design-oriented approach for supporting the architectural design projects of higher education, also fostering the sense of belonging among urban stakeholders.

The study is divided in two sections:

- Methodology definition.
- Case study application.

3. Methodology Definition

Despite the fact that several "*regenerative design*" theories have been developed, their approach is based on three common theoretical stages [19]: (i) to "*understand the relationship to place*"; (ii) to allow the "*designing for harmony with place*"; and (iii) to obtain the "*co-evolution*" of the design project. The present workflow connects these theoretical stages to three corresponding practical activities:

- Phase 1: Analysis of "understand the relationship to place".
- Phase 2: Design to allow the "designing for harmony with place".
- Phase 3: Education to obtain the "co-evolution" of the design.

Then, these activities are integrated with the actions defined by the Whole Building Design Guide (WBDG) [50] to consider the heritage features of the archaeological site, and specifically: identify, investigate, develop, execute, and educate. Finally, the process must be revised and restarted [31]. The scheme is reported in Figure 1.

3.1. Phase 1: Analysis

The analytical phase is structured in two subactivities:

- Identification of the main characteristics of the archaeological site at landscape, urban, and building levels.
- Investigation of the relationships between physical, natural, human, and economic systems.

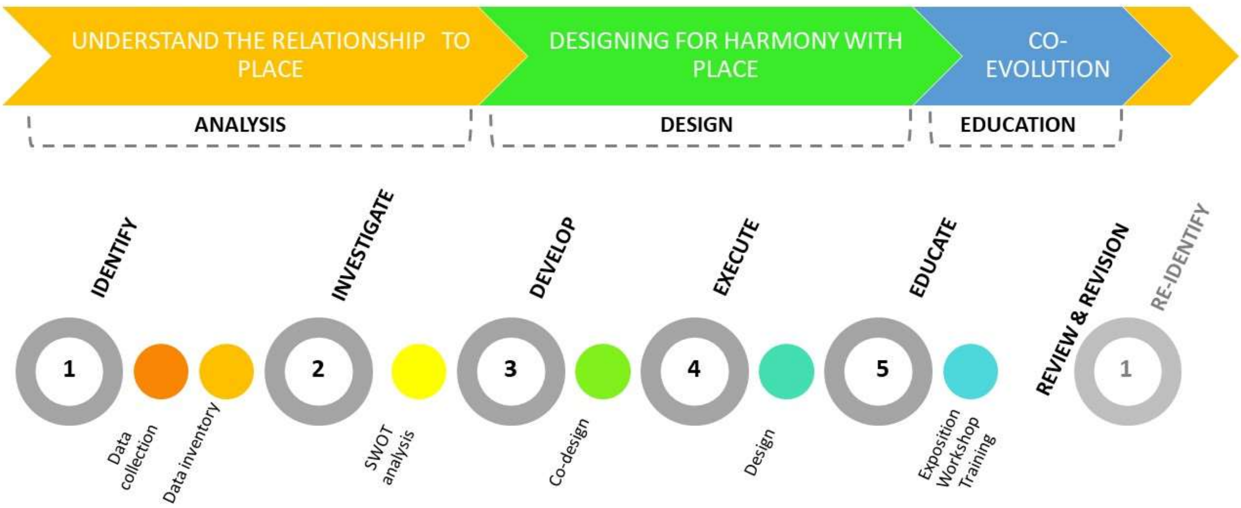

Figure 1. The proposed methodology for the regenerative design of archaeological sites (Author's elaboration).

3.1.1. Identification

Past, current, and future evolutions should be analyzed for identifying the main characteristics of the archaeological site [50] as a living system [19], prioritizing long-lasting effects to design advanced human and natural systems [30]. This approach requires deep and reiterated mapping and understanding of heritage, environmental, social, and economic dynamics and interactions [25]. To simplify the complexity of archaeological systems, this assessment is structured in two subphases:

- Data collection.
- Data inventory.

Data collection is based on the survey, a basic technique for identifying and documenting cultural and natural heritage resources. In this case, the survey looks at a wide range of patterns, covering multiple scales and different facets to boost the empathetical imagination for the architectural design project [19]. According to [12,14], the survey is divided into heritage, environmental, social, and economic factors. Heritage and environmental factors are inextricably intertwined [42]. They refer to historical, architectural, scientific, social, spiritual, and linguistic qualities and attributes possessed by landscapes, places, buildings, and artefacts [39]. These values should be associated both to tangible and intangible qualities [43]. Social aspects refer to the possible engagement of people and to the impact of the regeneration design on human needs [36]. Economic aspects concern the economic benefits of the process. Data collection should be supported by the following techniques: (i) archival research; (ii) urban data analysis; (iii) statistical data analysis; (iv) grey literature analysis; and (v) field investigation. The traditional heritage survey is based on archival research, urban and statistical data analysis, and field investigation [37,38]. Archival research and data analysis techniques provide information on heritage and environmental items, thanks to national and local records [17]. Field investigations are kinesthetic experiences based on the interaction with physical and social environments, to understand the state of the art of the of the archaeological site through active and experiential learning [51,52]. They permit appreciation of the area in a nonstructured way, increasing observational skills, contextual knowledge, and cognitive processes [51]. Grey literature is derived from journalism and social analysis to collect up-to-date information on the territory thanks to internet sites, social media, and newspaper articles. Finally, contextual inquiries are field interviews with visitors and community stakeholders to analyze needs, activities, and flows [53,54]. They are proposed for gathering a systematic survey of users' experiences from a long-term perspective [54]. Following a nonexhaustive matrix for data collection in an archaeological site is proposed (Table 1).

Table 1. Matrix for data collection in an archaeological site (source: Author's elaboration).

Sustainable Aspect	Technique	Sources	Data Collected	Level	
				Site	Building
Heritage	Archival research	Heritage records Local inventories Historical books Catalogues of typical construction materials Archival documents Historical images	Age and construction period Heritage values Geometrical features Architectural features Materials, techniques, workmanship History Archaeologic character Heritage-related legislation Changes over the time Integrity of design	■ ■ ■ ■ - ■ ■ ■ ■ ■	■ ■ ■ ■ ■ ■ ■ ■ ■ ■
	Urban data analysis	Cartographic documentations	Heritage constrains Historical evolution	■ ■	■ -
	Grey literature analysis	Internet sites	Presence of heritage sites in the area	■	-
	Field investigation	Visual analysis Video and photos	Dimensions Structure Materials and finishing Constructive details Materials, construction techniques Patterns Conservation level Time degradation Abandoned structures	■ ■ ■ - - ■ ■ ■ ■	■ ■ ■ ■ ■ ■ ■ ■ ■
	Contextual inquiry	Field interviews	Community value Local identity perception Management, conservation practices	■ ■ ■	■ ■ ■
Environment	Archival research	Heritage records Archival documents Historical images	Traditional flora and fauna Historical land use Historical urban grow	■ ■ ■	- - -
	Urban data analysis	Cartographic documents Topographic maps Aerial photos Satellite images Land registers Building regulations Local archives Photographic documents	Location Site layout Topography Hydrology Soil levels Solar orientation Heat island effect Land uses Urban-related legislation Local planning criteria, provisions	■ ■ ■ ■ ■ ■ ■ ■ ■ ■	■ - - - - ■ ■ - ■ ■
	Statistical data analysis	National database Local database	Microclimatic factors Energy labels Traffic data	■ - ■	■ ■ -
	Contextual inquiry	Field interviews	Human comfort perception Spatial perception Transportation systems	■ ■ ■	■ ■ -
	Statistical data analysis	National databases Local databases	Demographic profiles Number of tourists Tourist fluxes	■ ■ ■	- ■ ■
	Grey literature analysis	Internet sites Newspapers Reports	Transport facilities Transport networks Local parking	■ ■ ■	- - -
	Field investigation	Visual analysis Video and photos	Transport functionality Travel time Type of users Type of activities Interaction of activities Compatibility of activities People movements Education level of heritage staff Skills of heritage staff Service, facility, amenity delivery	■ ■ ■ ■ ■ ■ ■ ■ ■ ■	- - ■ ■ ■ ■ ■ ■ ■ ■

Table 1. *Cont.*

Sustainable Aspect	Technique	Sources	Data Collected	Level	
				Site	Building
Environment	Urban data analysis	Land registers	Provision of new facilities	■	■
	Statistical data analysis	National databases	Economic data on tourism Employment, unemployment rates Economic inactivity rates	■ ■ ■	■ ■ -
	Grey literature analysis	Internet sites Newspapers Social media Reports	Business location Local businesses Town centers, commercial hubs Economic wellbeing Innovation level of the area	■ ■ ■ ■ ■	- - - - -
	Field investigation	Visual analysis Video and photos	Local business Economic wellbeing	■ ■	- -
	Contextual inquiry	Field interviews	Evaluation of actual tariffs	■	■

Note: ■ = Data to be collected.

Data inventory contains all the collected information, documenting values, regulations, protection levels, conservation conditions, preservation priorities, etc. [17,51] with original maps, designs, sketch plans, photographs, and diagrams [37,38,50]. Heritage data must be geo-referenced for localizing each aspect on distribution maps [50].

3.1.2. Investigation

The systematic investigation of these data aims at mapping the relationship among different variables for outlining risks, problems, hazards, needs, challenges, and opportunities for the regenerative design process [50]. The proposed method is based on the evaluation of strengths, weaknesses, opportunities, and threats, also called SWOT analysis. This phase is fundamental for underpinning possible transformations; transmitting the knowledge of the past; and enhancing heritage values, biodiversity, and landscape design, as well as for generating economic and social opportunities [51]. A matrix of specific elements to consider is delineated below (Table 2).

Table 2. Matrix for the archaeological site evaluation through the SWOT analysis (source: Author's elaboration).

<table>
<tr><td rowspan="4">Sustainability
Heritage
Environment
Society
Economy</td><td>1. Competitive advantages
2. Resources
3. Well-performing aspects</td><td>1. Disadvantages
2. Lack of resources
3. Underperforming aspects</td></tr>
<tr><td>Strengths</td><td>Weaknesses</td></tr>
<tr><td>1. Favorable external factors
2. Specific potentials
3. Specific possibilities</td><td>1. External pressures
2. Potential harmful factors
3. Challenges</td></tr>
<tr><td>Opportunities</td><td>Threats</td></tr>
</table>

Example of key questions based on analysis of these data are: "*What are the dynamics and the relationships between environmental, social, and economic systems?*", "*Does the site need to change?*", "*What are the major issues for improving its performance?*", "*How can positive values for the stakeholders and the local ecosystem be added?*". These basic questions help professionals and heritage and public authorities in making informed decisions for planning, design, and management purposes. The SWOT analysis for the regenerative design process is a continual flow of matters through a living system [19], not a static configuration. Thus, it is important to repeat this investigation for each modification of the design process.

3.2. Phase 2: Design

The design phase is structured in two subactivities:

- Development of key design principles and schemes.

- Execution to translate the key design principles into systemic designs, integrated plans, and construction processes.

3.2.1. Development

The deep knowledge of needs, risks, and priorities is the starting point for defining tailored interventions on buildings and landmarks [21]. An interactive relationship among all the professionals involved in the design process is proposed for reducing project unknowns and change orders and helping in quality control [25]. Consultation and people's engagement are fundamental for defining insights, key principles, and alternative solutions [21,25] as well as for minimizing operational energy demand, consumption, and carbon dioxide emissions [47]. The generative cocreation methods normally used in social science are selected to structure heritage, natural, human, and economic systems in a dynamic way [52]. Several methods can be used, but the most useful for inspiring creative design is the experience interview with designers, public and heritage authorities, owners, and local organizations [52,53] because it permits gathering technical aspects in a narrative way, managing the changes of the place in a conscious way, and negotiating design targets [25]. This technique has a clear focus on users' experiences [52], without requiring the knowledge of psychological models, such as cards use (e.g., needs, emotion granularity, and wellbeing determinant cards), or scientific methods (e.g., UX Concept Exploration and day reconstruction method) [52]. Following a nonexhaustive matrix of the items to discuss in codesign sessions is proposed to harmonize stakeholders' needs with the larger pattern of ruins, buildings, landscapes, infrastructures, and services, also improving the economic benefits of the area (Table 3).

Table 3. Matrix for defining the items to discuss in the codesign working tables of an archaeological site (source: Author's elaboration).

Technique	Sustainable Aspect	Stakeholders Involved	Item Discussed	Level	
				Site	Building
Experience interview	Heritage	HA, archaeologists, heritage/museum staff, owner	Heritage constrains	■	■
			Urban constrains	■	■
			Conservation level	■	■
			Materials, construction techniques	-	■
			History	■	■
			Chrono-mapping	■	■
	Environment	Archaeologists, PA, HA, management staff, owner	Urban-related legislation	■	■
			Local planning criteria	■	■
			Building-related codes	-	■
			Functional plan	■	■
			Use of natural resources	■	-
			Signals and facilities	■	-
			Equipment, furniture, services	■	■
			Management procedures	■	■
			Sustainability and energy policy	■	■
			Waste/water management	■	■
			Conservation level	■	■
			Human comfort perception (staff)	■	■
	Society	PA, HA, owner, community associations	Users' perceptions	■	■
			Users' needs	■	■
	Economy	Owner, PA	Evaluation of management costs	■	■

Note: ■ = Data to be collected.

3.2.2. Execution

Many regenerative design projects fail to achieve an effective outcome for the absence of the systemic connections [19]. For this reason, the proposed workflow is based on the Integrated Design Process (IDP), a transdisciplinary, open, conscious, and participatory method that considers "multifaceted systems thinking" from the beginning [29]. The disciplines to be involved are at least urban planning, landscape design, architecture, engineering, restoration, agriculture, agronomy, geology, ecology, biology, climatology, physics, sociology, psychology, and economy [20,25]. Regenerative design requires schematic designs (rough sketches and drawings that illustrate the basic idea), design developments (plans, prospects, sections, axonometries, and renderings that illustrated the design concept in detail), construction drawings (technical specifications, details, notes necessary for bidding, permit application, and construction), computer simulations (energy, daylighting, and computational fluid dynamics), and technical documentation (cost and time management, building quality control, and commissioning). The design process should be supported by urban and building green rating tools during the early stage for determining the sustainability level of the project [55–59]. At the urban level, the Building Research Establishment Environmental Assessment Method (BREAM®) Communities (BREAM® C) [60–62] results are the most indicated for evaluating heritage aspects in regenerative projects [63,64]. At the building level, the Green Building Council (GBC) Historic Building Protocol is specifically realized for assessing heritage buildings [65,66].

3.3. Phase 3: Education

Education activities require on-site expositions, local workshops, and training opportunities for illustrating and discussing the design project with the stakeholders, also improving people's engagement to boost the regenerative design of the archaeological site.

4. Methodology Application

According to the Sustainable Development Goals (SDGs) n. 4, 7, 11 and 13 [9], this workflow has been experimented with at the architectural Design Studio of the Polytechnic of Milan to ensure adequate knowledge and skills for the learners for comprehending and responding to the challenges of sustainable development. Design studios are important experiences for developing architectural sensitivities, communicative abilities, and problem-solving skills for future architects [67,68]. In this specific case, 54 students from several international countries (e.g., Italy, Germany, Poland, Spain, Canada, Brazil, China, India, Korea, Japan, Israel, etc.) worked in teams of 4–5 people on the same project. Professors helped them to solve specific design problems with theoretical and practical backgrounds. Training focused on legislation, architectural restoration (e.g., criteria, principles, working phases, and materials), technology of architecture (e.g., building materials, construction systems, and innovation in the building sector), and building physics (e.g., sustainability, energy efficiency, green design, renewable energy sources, lighting, and acoustic design). Furthermore, the design process was supported by the key players of the site (owners, local HA, province, municipality, and local associations), to create a shared vision of the sustainable regeneration of the area [50].

4.1. Phase 1: Analisys

The methodology was applied to the UNESCO site of Castelseprio, an archaeological area situated in the province of Varese inside the natural park of the "Olona River" (Lombardy Region). As introduced in the methodology framework, the analytical phase was divided into:

- Identification.
- Investigation.

The results of each subphase are reported below.

4.1.1. Identification

The design project started with the collection and the inventory of a series of data relating to heritage, environmental, social, and economic characteristics. This preliminary study outlined urban and architectonic features as well as socio-economic characteristics. Data collection at urban and building levels was supported by archival research, urban, statistical, and grey literature data analysis, as well as by field investigations and contextual inquiries with the stakeholders (tourist, visitors, and staff). Urban data concerned:

(i) historical, environmental, social, and economic development; (ii) environmental conformation and morpho-topological structure; (iii) climatic data; (iv) heritage and natural values; (v) legislative framework; (vi) conservation and maintenance levels; (vii) accessibility and transport systems; (viii) touristic aspects; (ix) human needs and activities; and (x) future provisions. The location of the building is reported below (Figure 2).

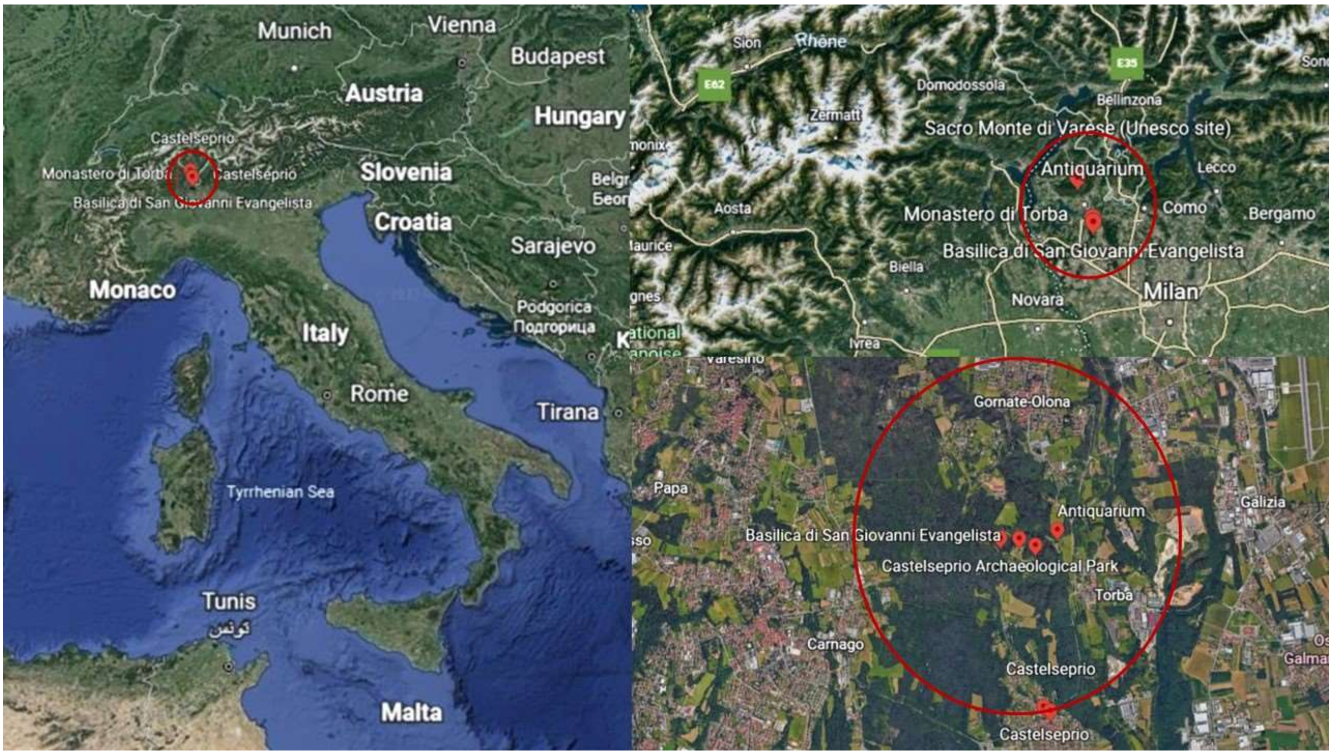

Figure 2. Map of the area (Source: Author's elaboration from Google Earth).

Building data referred to an existing museum that requires a deep building retrofit and refers to: (i) history; (ii) shape, typology, and dimensions; (iii) materials and constructive technologies; (iv) microclimatic data; (v) heritage values and aesthetic design; and (vi) conservation and maintenance level. The information was synthetized and illustrated in specific relations and graphical studies on heritage, environmental, social aspects. The history of the archaeological site was reconstructed, discovering that the place reached as far back as prehistoric and protohistoric times, while several artifacts came from the Bronze and the Early Iron Ages. Its history was linked to the strategic position between road Novaria-Comum, a Roman road that connected the cities of Novara and Como. This position led the founding of a fortified citadel (called Castrum Sibrium) of the V-VI century. Most buildings were built in Byzantine and Medieval periods. Belonging to this period were both heritage (e.g., the Churches of Santa Maria Foris Portas, San Giovanni Evangelista, and San Paolo, the noble house, and the Torba Monastery) and vernacular buildings. Traditional houses and living quarters were designed as independent units, or multistory forms with similar typologies, but with different colors, finishing, and patterns. The citadel maintained its prestige during the Middle Ages (IX–XI Century), but it was destroyed in 1287 by the Archbishop of Milan, Ottone Visconti, to prevent its use by rivals. The first ruins were discovered in the XIX century around the passion of ancient buildings and collections. Then, deforestation activities revealed the presence of an old settlement (1944). The archaeological park was established in 1950 after continuous deforestation work, and excavation campaigns discovered several ruins and ancient objects. It became a UNESCO site in 2011, providing the experience of a medieval settlement (Figure 3).

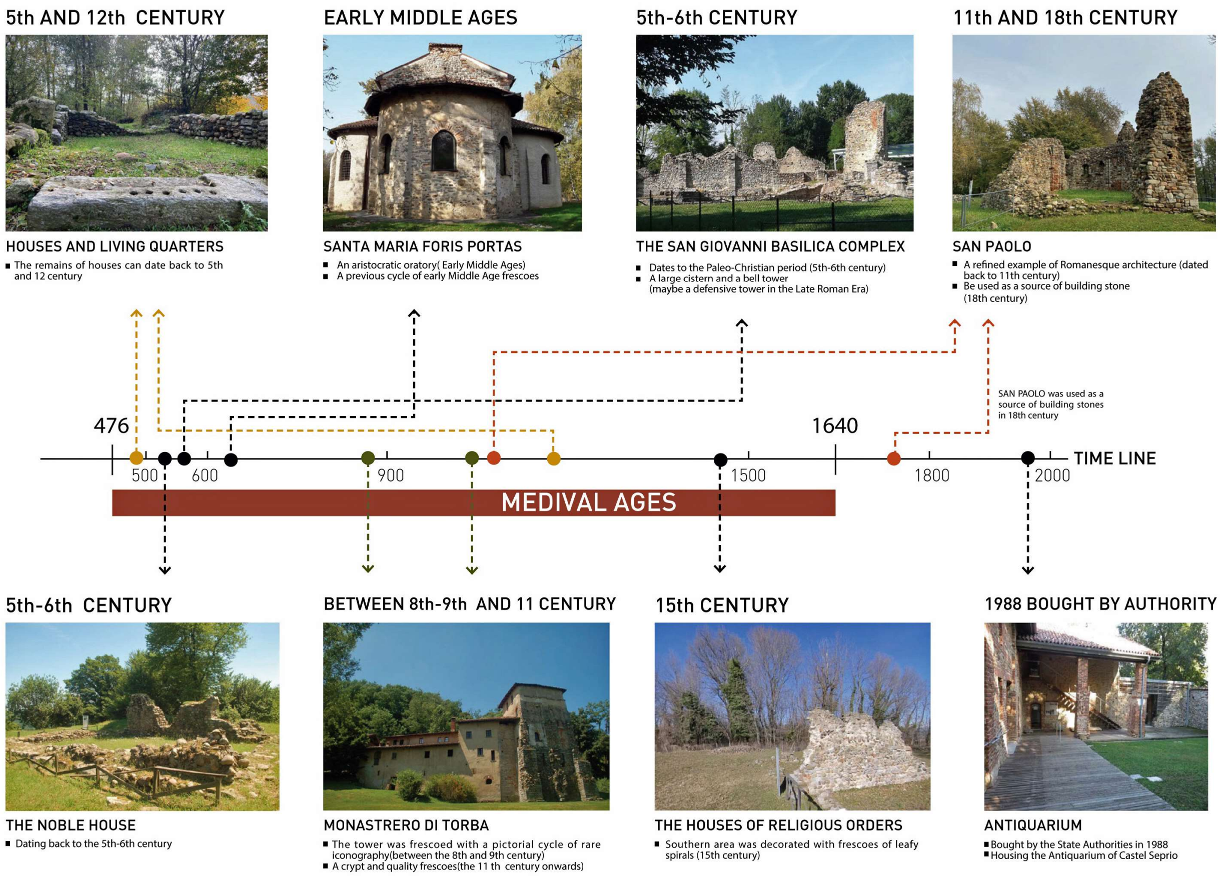

Figure 3. The history of the archaeological site of Castelseprio (Source: Design team composed of the students Jia Liao, Zhifeng Li, Patrycja Pisarek, Mengya Wu, and Lei Zuo).

Also, archival research, urban data analyses, and field investigations were important to recognize heritage values, typical constructive technologies, and traditional materials (Figure 4).

Furthermore, urban, statistical, grey literature analysis, and field investigations enabled the classification of environmental patterns and land uses. Contextual inquiries and spatial analyses supported the evaluation of users' needs in terms of activities, times, and their interactions (Figures 5 and 6).

4.1.2. Investigation

The SWOT analysis was conducted at urban and building levels to identify potentials and problems of the archaeological site. At the urban level, (Table 4) positive elements referred to the high historic and natural values, thanks to the presence of well-conserved settlements and high biodiversity. Negative elements concerned the presence of abandoned buildings and inaccessible ruins as well as of aged and low-maintained facilities and amenities (e.g., benches and fences). Although the site was covered in lush green, proper maintenance was lacking. Furthermore, the site was not fully accessible to public transport and for visitors with limited mobility.

At building level (Table 5), positive points referred to historic values, good conservation levels, passive energy strategies, and bioclimatic measures. Problems concerned the overlapping of functions, waste of spaces, segregation of visitors and archaeologists, and low human comfort performances.

This embodied knowledge was used to underpin the regenerative design process through the codesign phase for collecting suggestions, corrections, and discussions to improve the quality of the results.

4.2. Phase 2: Design

The design phase was illustrated from ideation and conception through planning, project proposal, and technical engineering. Codesign was supported by several hands-on trainings devoted to the exploration of the most important urban, architectonic, artistic, and social aspects involved in the design practice. Furthermore, a series of experience interviews with local HA, PA, archaeologists, and owners were realized, to collect more practical information. Keywords gathered before and after the codesign experiences were discussed in specific focus groups. Key design principles originated from their comparison (Table 6).

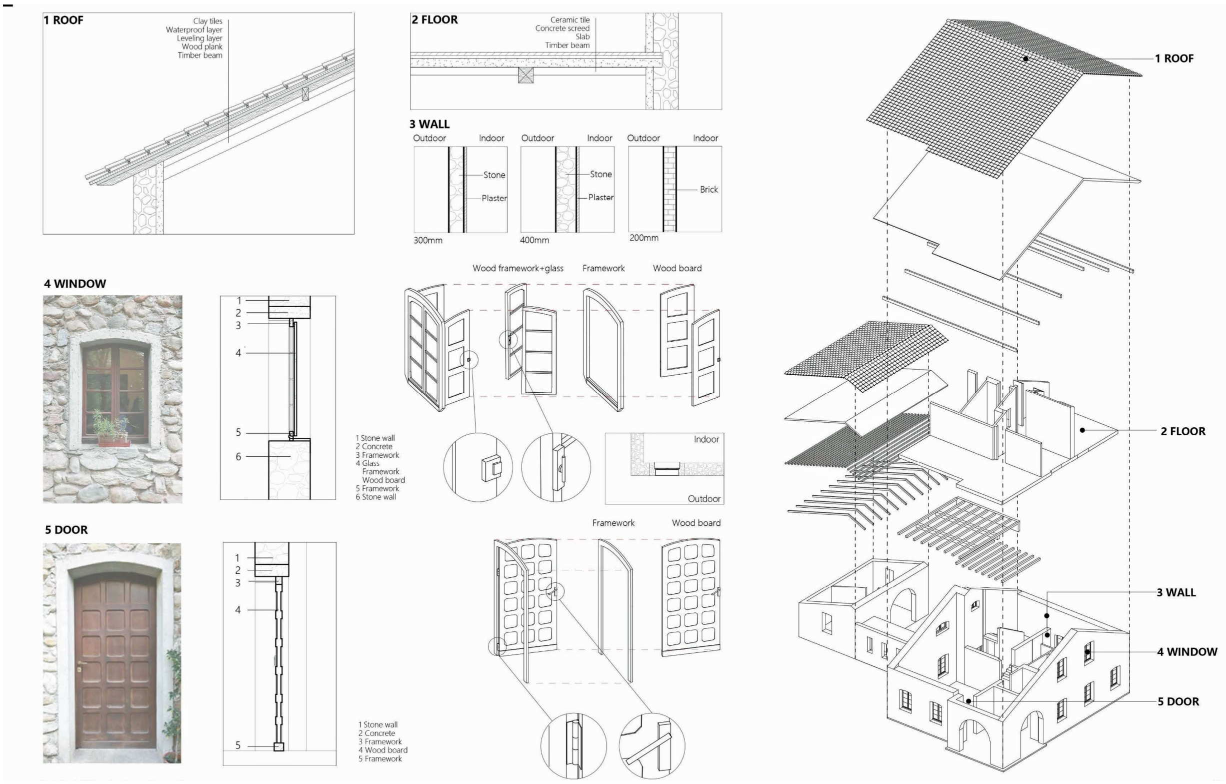

Figure 4. Abacus of typical constructive technologies of the main building in the archaeological site of Castelseprio (Source: Design team composed of the students Wei He, Huiyuan Jiang, Tong Li, Jingwen Shen, and Haoran Wu).

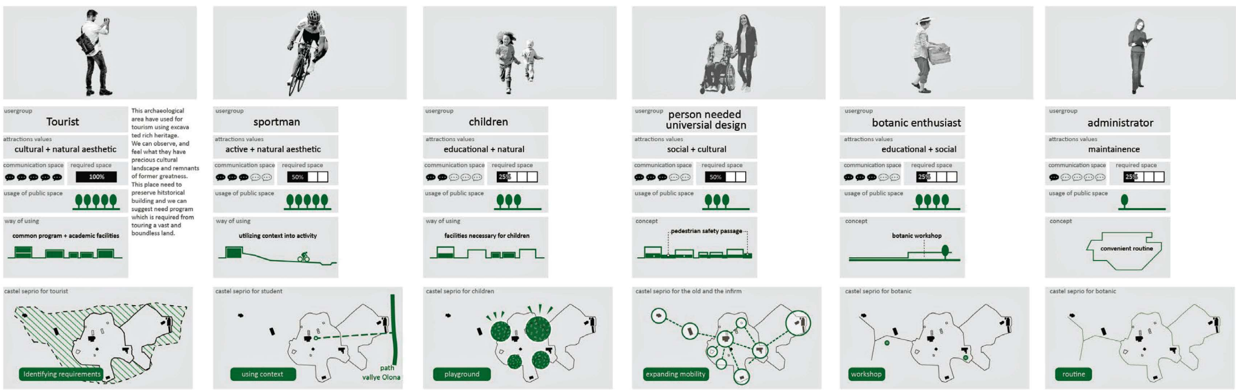

Figure 5. Users' activities in the archaeological site of Castelseprio (Source: Design team composed of the students Sameeullah Ashraf Ali, Soyoung Kim, Hemant Powar, Xiangyao Tan, and Yuqing Wang).

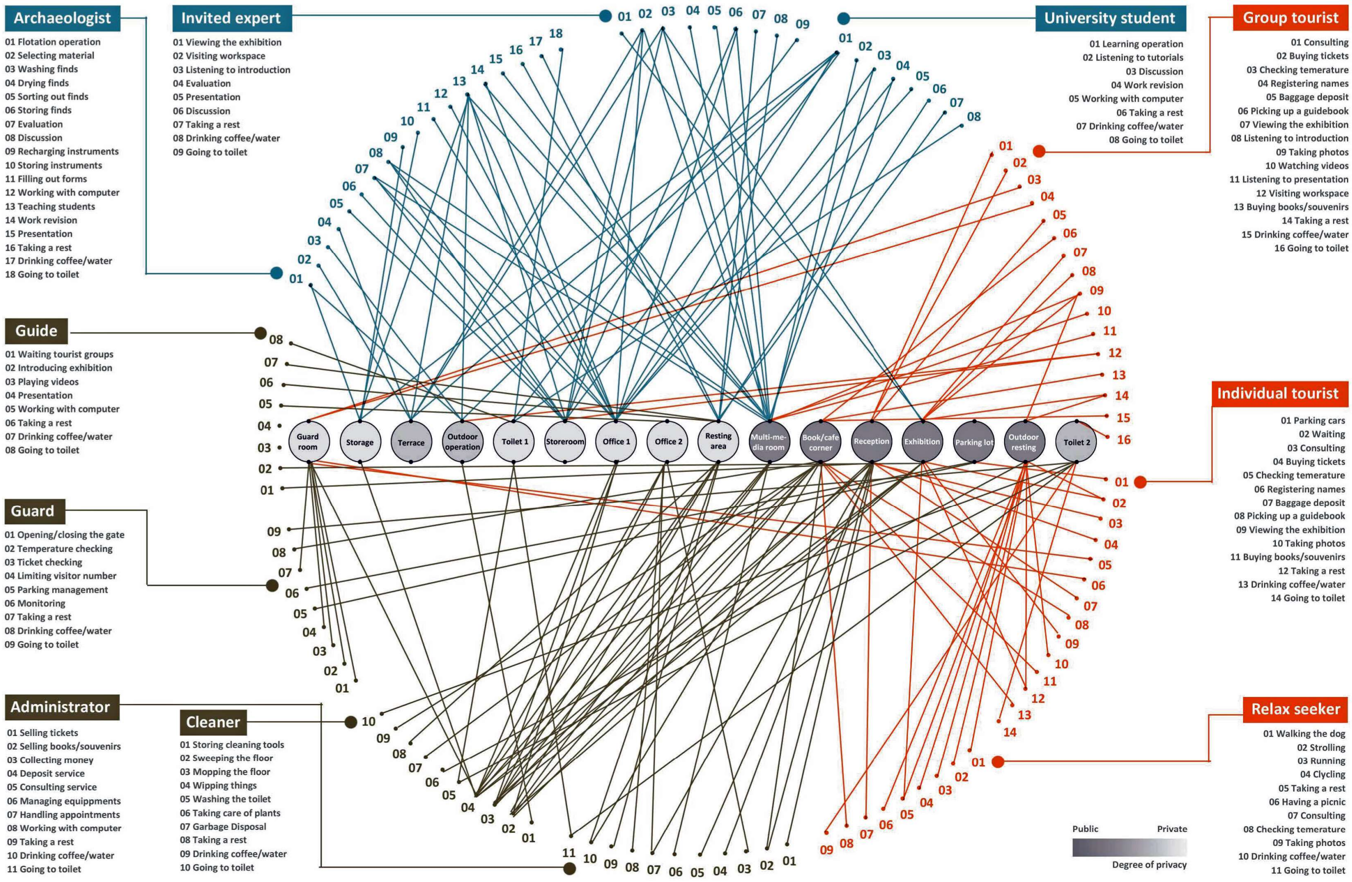

Figure 6. Interactions among the activities of different users in the archaeological site of Castelseprio (Source: Design team composed of the students Wei He, Huiyuan Jiang, Tong Li, Jingwen Shen, and Haoran Wu).

Table 4. Application of the matrix for the SWOT analysis to the UNESCO archaeological site of Castelseprio at urban level (source: Author's elaboration).

Sustainability	Strengths	Weaknesses	Opportunities	Threats
Heritage	High heritage values	Strict ruin protection	Providing a comfortable, welcoming, and friendly cultural environment	Heavy rains disturbing excavation process
	Well-conserved archaeological site	Presence of abandoned buildings		
	UNESCO site	Inaccessible primary ruins and underway excavations	UNESCO World Heritage status will serve as a guideline	Badly maintained facilities
Environment	High natural values	Not reasonable functions and distribution	Possibility of using renewable energy	Absence of sidewalk in the entrance way
	Rich natural surroundings	Difficult to access by public transport	Possibility of using rainwater	Presence of wild animals have potential to damage ruins
		Insufficient parking	High solar potential	
	Well-conserved natural site	Onsite vehicle access diminishes the pedestrian experience	Enhance hiking and cycling activities by the creation of new routes	Prone to weather incidences (e.g., fallen trees)
	Multicolored biodiversity	High temperature conditions in summer season	Existing hiking trails can easily accept new trails	Separation of the site by height
	Proximity to local cycle path	Strong winds requiring high resistance objects	Presence of local cycle path to be continued	Steep landslide depriving water from the hill
	Important green area for local and regional biosystem	No facilities to reduce outdoor weather conditions	Strong winds enabling generating energy	Uneven landscape will prove challenging for disabled/elderly accessibility
		Ground surface not absorbing water	Excavated soil and stones to be reused	

Table 4. *Cont.*

Sustainability	Strengths	Weaknesses	Opportunities	Threats
Society	Already known by the community	Absence of signals and touristic information	Remark the visual memory of the site	Balance between staff and visitor needs
		Lack of touristic organization	Religious presence on site	
		Sense of loss inside the site		
		Some areas are unknown/missed	Provide the community a space for activities/events	Users causing damage to the archaeological site or ruins
		Different protection levels across the site		
		Difficulty of movement of people with disabilities		
Economy	Famous archaeological site	Lack of funding	Potential economy values	
	Easy to be promoted		Potential large flows of people	
	Important heritage site			

Table 5. Application of the matrix for the SWOT analysis to the archaeological site of Castelseprio at building level (source: Author's elaboration).

Sustainability	Strengths	Weaknesses	Opportunities	Threats
Heritage	High heritage and historical values	-	Presence of several historic documents	Connection between historic and new constructions
	Vernacular aesthetics		High flexibility for building renovation	Conservation of the historic values
	UNESCO site			
Environment	Information building located at the entrance of the site	Not reasonable functions and distribution	Build an extension to provide space for activities	Upgrade of the energy and environmental performances
		Poor spatial organization		Building accessibility
	Presence of an available courtyard	Not friendly and welcoming building	Introduction of new functions	Improvement of the spatial quality
		Absence of indoor natural ventilation		
	Adequate energy performance of building masonries	High temperature and relative humidity inside the building	Adoption of passive strategies for energy retrofit	Building positioned between trees (possible construction and maintenance problems)
		Poor indoor hygrothermal, visual, and acoustic comfort		
	Well-conserved information building	Low energy performance of windows	Bioclimatic and biophilic design	Materials not suitable for recycling
		Short service life		
		High carbon emission		
		Waste of water		
Society	-	Lack of space for archaeologists and for learning activities	Introduction of new functions according to users' needs	Balance between staff and visitor needs
		Architectural barriers		
Economy	Large flow of people	-	-	-

Execution

Eleven design projects were realized according to the key principles of regenerative design discovered through the codesign process (Table 6). Heritage and environmental protection were the founding pillars of all projects. '*Heritage conservation, enhancement, and management*' started from the respect of the high value of ruins, old buildings, archaeological manufacts, and surrounding landscapes. Instead of demolition and redevelopment, the adaptive reuse of existing buildings and ruins was preferred to preserve their values. New additions were based on '*flexibility and adaptability*' of spaces, infrastructure, structures, layouts, and furniture. Functional mix, multipurpose buildings, and flexible rooms for collective activities (e.g., meeting, training, education, association, shopping, gaming, exposition, etc.) were suggested to favor the exchange between visitors, staff, inhabitants, and associations. Similarly, structural modularity, and dry-construction systems made by lamellar wood or recycled iron were chosen for facilitating horizontal and vertical expansion. These ideas were strongly connected to '*reversibility and recognizability*' criteria; to remove fastening systems, assemblies, and installation methods without any damage [69];

and to recognize new additions thanks to the use of different materials, textures, and colors (Figure 7).

Table 6. Keywords and key design principles for the regenerative design of the archaeological site of Castelseprio (source: Author's elaboration).

Design Keywords		**Key-Design Principles**
Before Co-Design Experience	**After Co-Design Experience**	
		
Regeneration	Regenerative	
Eco	Regeneration Social regeneration	Regenerative design
Sustainable	Sustainable Awareness	
Reuse	Cultural heritage Archaeological work History Culture Preservation Heritage value Conservation	Heritage conservation, enhancement, and management
Flexible	Dynamic spaces Multifunctional space	Flexibility and adaptability
Affordance	Addition Merge Bridge	Reversibility and recognizability
Biophilia design	Biophilic Landscape architecture Landscape design Green design Art site	Biophilia and landscape design
-	Environment Site Water	Environmental and water preservation
-	Accessibility	Accessibility and universal design
Circular	Natural materials Circular economy Circular Disassembly	Natural materials and circular economy
Efficient	Retrofitting Passive house Energy saving	Deep energy retrofit

Table 6. *Cont.*

Design Keywords		Key-Design Principles
Before Co-Design Experience	**After Co-Design Experience**	
		**Key-Design Principles**
Renewable	Renewable energy	Renewable energy
Comfort Climate Wellness	Comfort Health Wellbeing	Human comfort and wellbeing
Interaction Interactive Humanization Emotion Atmosphere	Interactions Interactive Relationships Emotions Atmosphere	Emotional design
Sensory suggestion	Community Community impact Communication Education Curiosity User-friendly	User-centered design
-	Journey Storytelling Attractive	Open-air architectural park
Green Protocols	Green protocols LEED BREAM	Green rating systems

Environmental needs were defined through the SWOT analysis for improving landslide defense, wind resistance, water supply, rainwater adsorption, human comfort, accessibility, and maintenance (Table 4). Nature-based solutions contributed to sustainability and resilience through the provision of ecosystem services, such as local climate control, air quality regulation, water purification, soil, and water retention. To this purpose, '*biophilia and landscape design*' aimed at creating a direct contact between natural and built environments, increasing the permeability of artificial forest boundaries thanks to the design of new pathways, slope protections, and panoramic watching decks. Organic shapes, repetitive geometric flourishes, porous constructions, and warm earth tones, as well as local, natural, and recycled materials were selected. Similarly, '*environmental and water preservation*' (e.g., control and treat stormwater, reuse and recycle water for on-site use) were considered important elements for supporting the relationship with nature. In a project, the rain garden tried to solve landslide susceptibility by capturing rainwater and reducing surface runoff. Here, superficial pebbles and sand favored the habitat of insects and the growth of roots. Plants were selected from native flora, to gradually allow the development of small biological communities. New structures and facilities were designed without heavy installations and impacts on soil, to be easily removed (Figure 8).

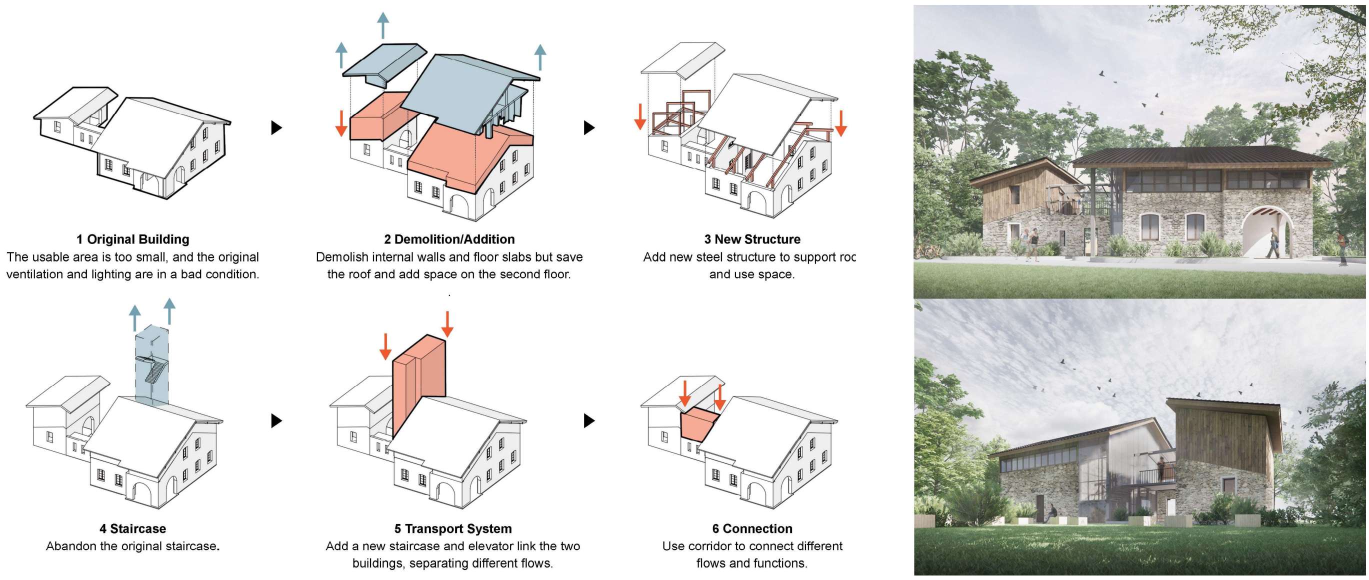

Figure 7. Reversibility and recognizability (Source: Design team composed of the students Wei He, Huiyuan Jiang, Tong Li, Jingwen Shen, and Haoran Wu).

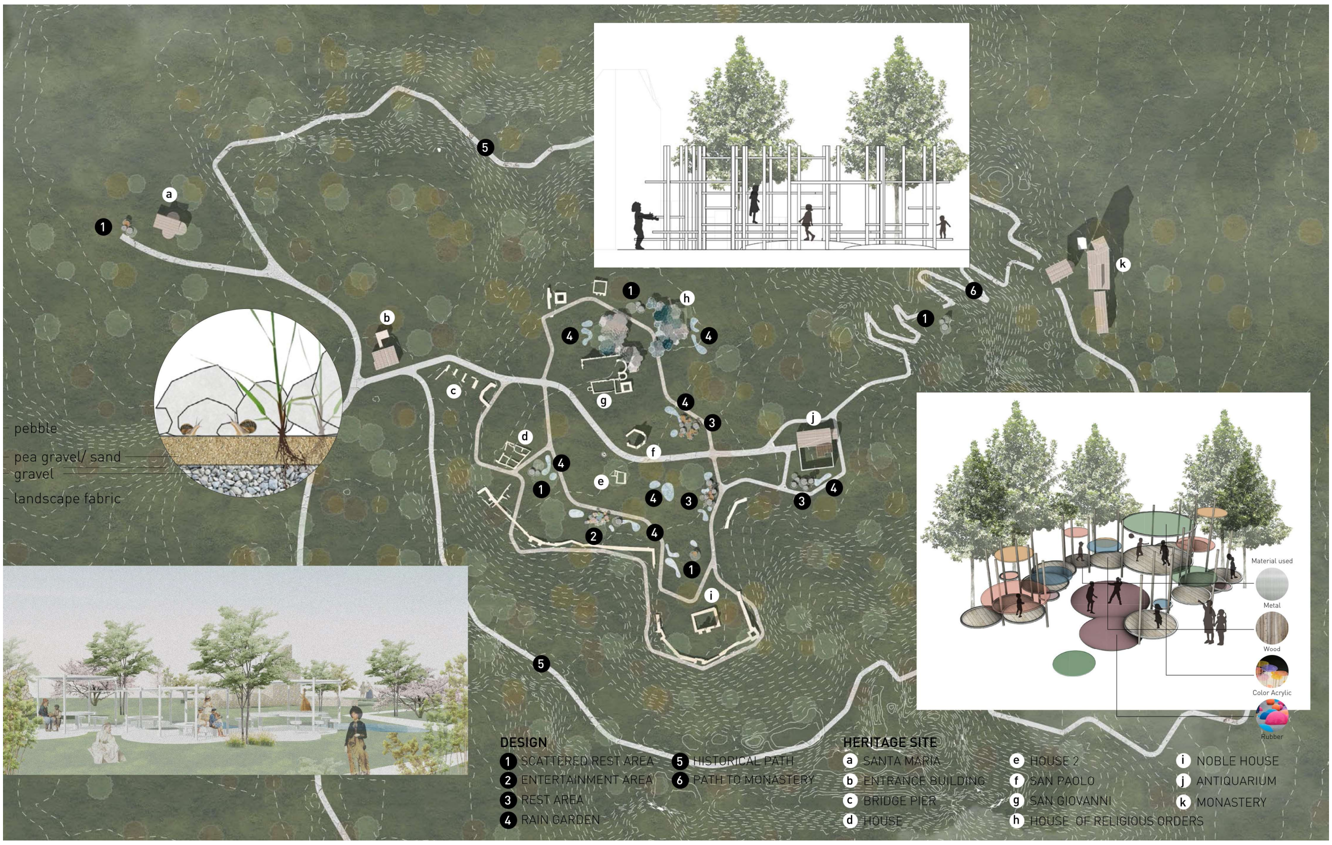

Figure 8. Biophilia and landscape design (source: Design team composed of the students Jia Liao, Zhifeng Li, Patrycja Pisarek, Mengya Wu, and Lei Zuo).

'*Accessibility and universal design*' of the site were improved in different ways: small-scale electric car shuttle services from public transport nodes, absence of architectural barriers, flat areas (for playscapes, workshops, terraces, picnics, and bird watching), gentle slope pathways, shelters, benches, tactile signages, and surfaces. In addition, the sizing of pathways considered people flows by allowing bicyclists, pedestrians, and those with disabilities to travel through the area without interference. In one project, the roads around the site were also designed to allow the passage of emergency and maintenance vehicles. Heritage as economic resource was another pillar of the projects. Two main approaches were considered. First, '*emotional design*' aimed at activating positive responses of visitors through new didactic and sensitive routes, appealing furniture, sensory involvements, user-friendly interfaces, effective visual elements, smart devices, and engaging contents (Figure 9).

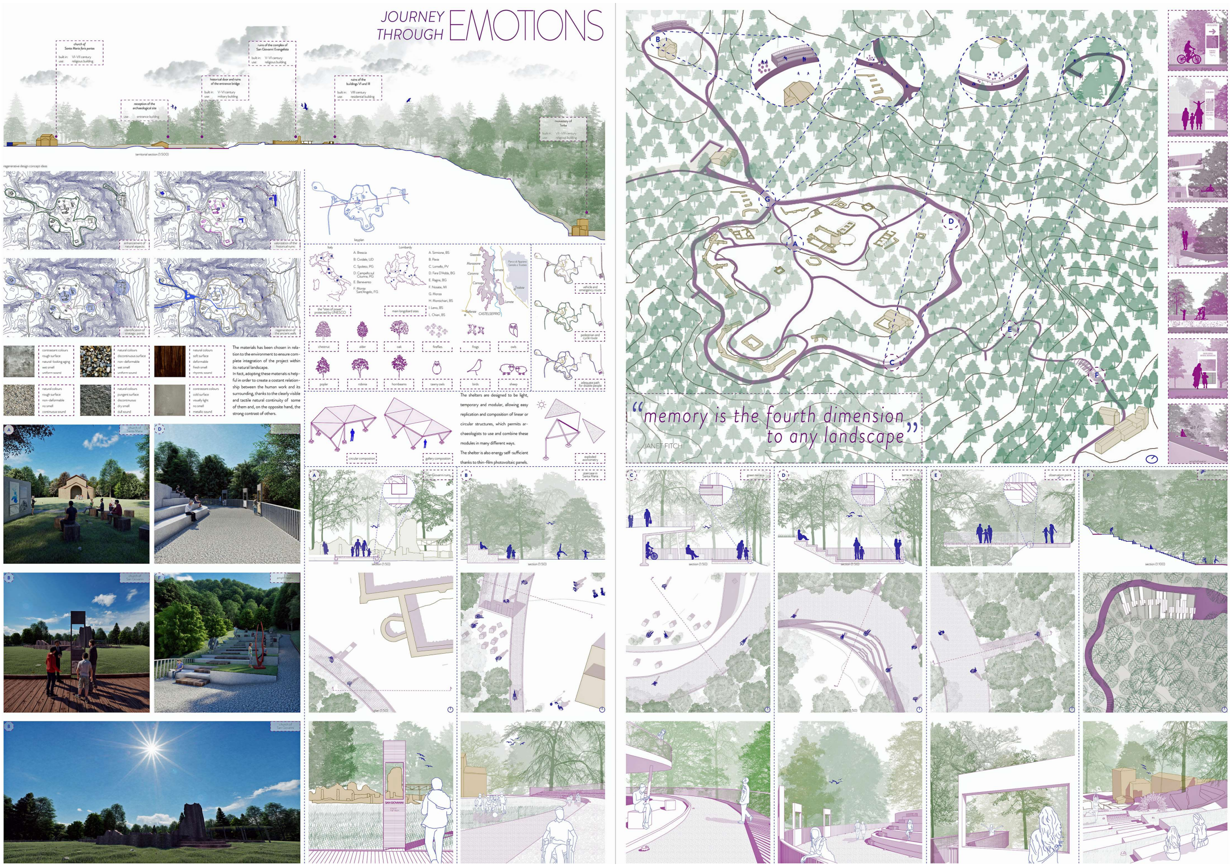

Figure 9. Emotional design (source: Design team composed of the students Claudia Ancona, Giulia Aretino, Luca Attinà, and Radmila Biafore).

Furthermore, the '*open-air architectural park*' aimed at balancing heritage preservation, regeneration, and community-focused economic returns through an interactive and leisure-oriented approach for different touristic groups. To this purpose, interactive info points, systems for simulating the original form of structures, and pathways with storytelling were designed (Figure 10). Both approaches were based on a '*user-centered design*' for understanding users' needs and objectives and to create a positive interchange with the local community (e.g., user participation into cultural activities, heritage associations, and local farm creation). This may generate economic benefits linked to the improvement of slow tourism, education activities, and creative industries. '*Natural materials and circular economy*' were used to ensure low levels of embodied and operational carbon emissions, and to reduce construction time. Disassembly strategies; flexible constructive schemes; demountable wall panels; and natural, raw, recyclable, and reclaimed materials (e.g., recycled plastic bottles, rice, wood, leather, bamboo, paper, and coconut fibers) were selected to minimize waste (Figure 11). Moreover, the re-appropriation of vernacular shapes, local materials, and techniques contrasted the globalization of the construction process. This may produce also economic benefits for the creation of long-term jobs and spillovers related to traditional craftsmanship. In parallel, waste management was crucial to characterize the livability and the functionality of the place. These strategies were applied at urban and building levels, in the last case both on existing buildings and new additions.

At building level, the key design principles of '*deep energy retrofit*', '*integration of renewable energy*', and '*human comfort and wellbeing*' were considered as a whole element. In all the architectural projects, passive design, energy efficiency, and renewable energies strategies were adopted. The passive design approach harnessed all the potential advantages from the site, surroundings, and climate. For this purpose, bioclimatic internal layouts, sun and wind orientations, vegetal shading systems, evaporative cooling, daylighting, and natural ventilation were chosen. In parallel, energy efficiency strategies considered natural-based insulation materials, high airtightness, high performance glazing, task lighting with lighting sensors, mechanical ventilation systems with heat recovery, high-efficiency heating, ventilation, air conditioning (HVAC) systems, indoor set point temperatures, and integrated photovoltaic (PV) systems (e.g., colored and thin film PV) for reaching the self-sufficiency of energy consumption [70,71]. Finally, green rating tools were used as design-support schemes for selecting different interventions during the design phase, to nail down every sustainability feature, and to maximize the environmental benefits. BREAM© C and GBC HB were respectively used at urban and building levels.

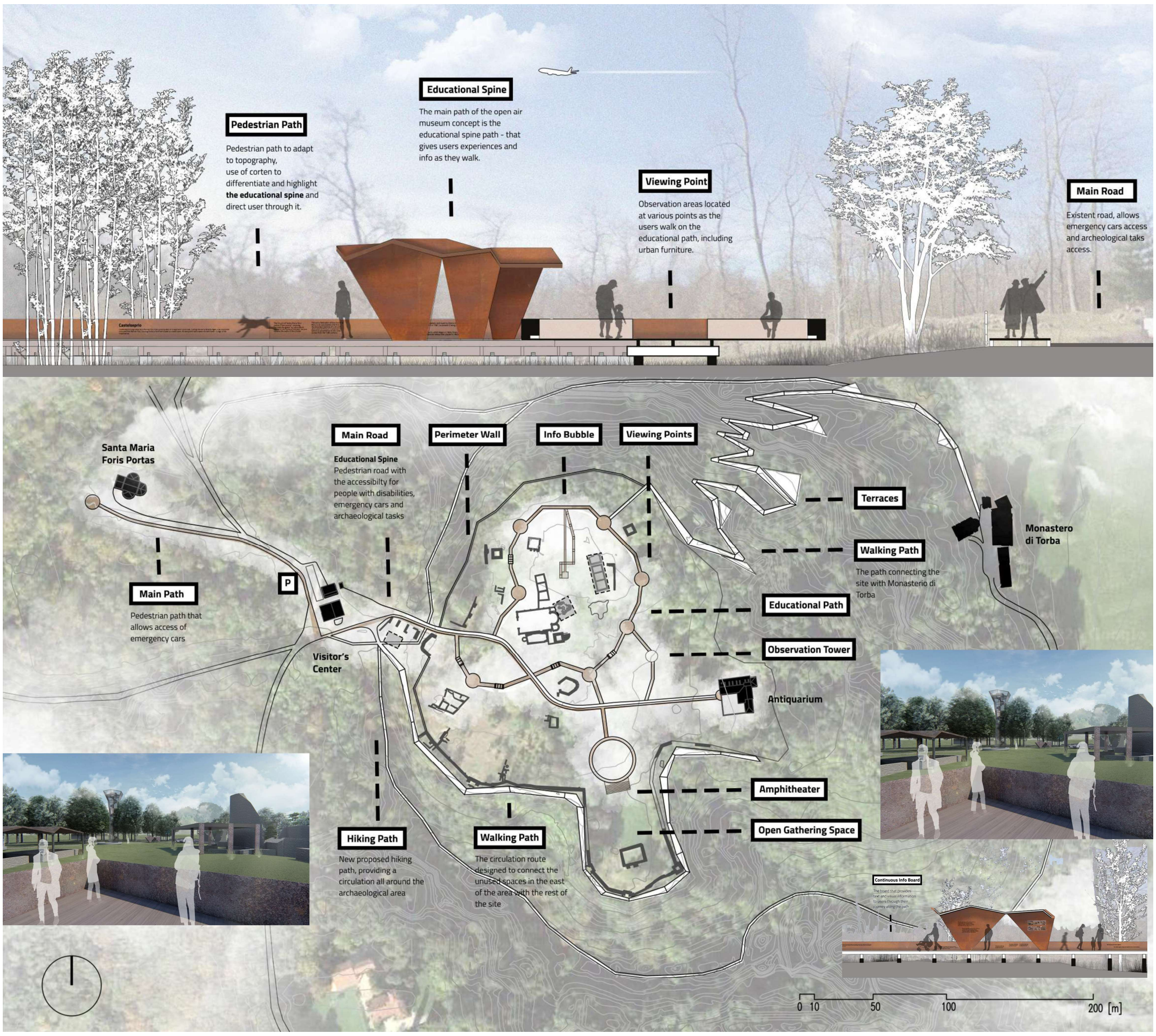

Figure 10. Open air architectural park (source: Design team composed of the students Andrew Barat, Andras Domokos, Andrea Sibaja, Berrak Gonul, and Camilla Quaglione).

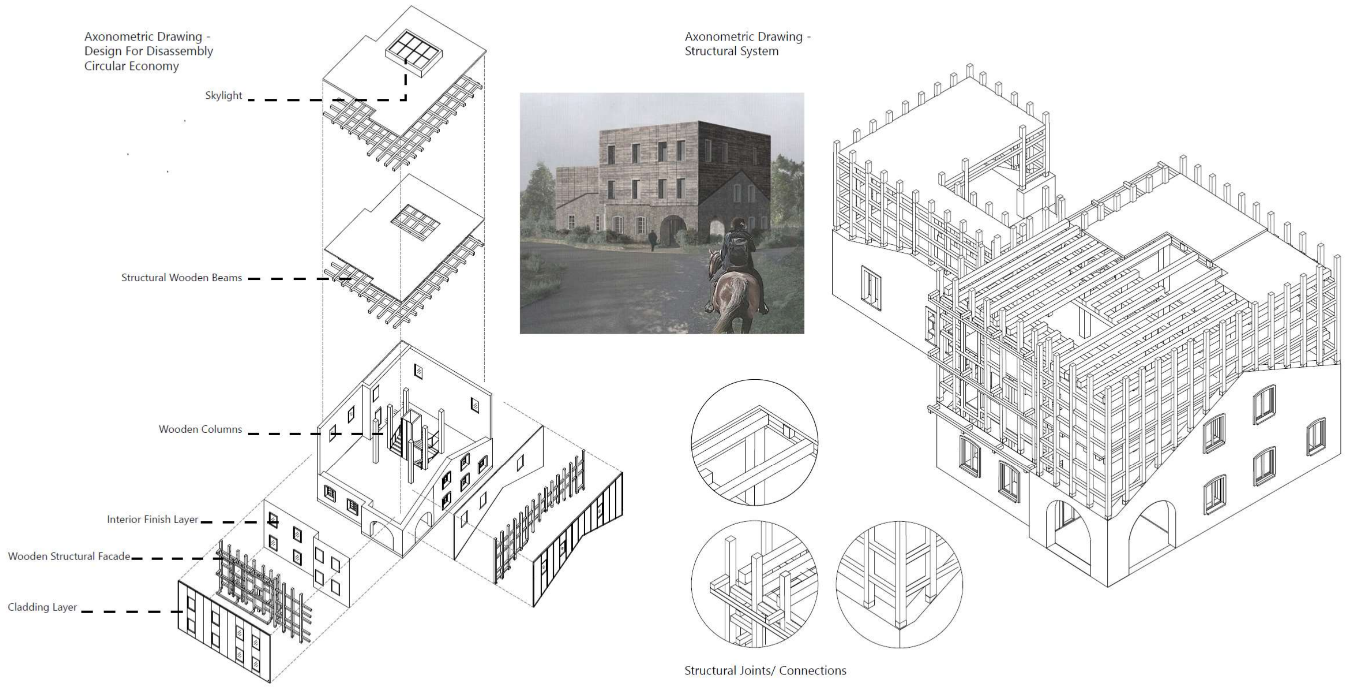

Figure 11. Natural-based materials and circular economy (source: Design team composed by the students Emmanouela Aligizaki, Fran Jalsovec, Krzystof Lichocik, Elahe Malekzadeh, Basel Rihani).

4.3. Phase 3: Educate

Stakeholders were involved in the design project from the beginning thought several workshops with PA, HA, and owners to present the design ideas. In addition, posters and wayside signals were exhibited in the archaeological sites for generating interest in the project fostering the heritage revitalization.

5. Discussion

Comparing with a traditional pedagogical approach, the regenerative design approach permits a complete overview of the site, considering not only urban and architectural issues, but also social, economic, natural, and heritage issues thanks to the integrated vision of different disciplinary fields. This methodology allows the definition of key design principles and shared criteria for the regenerative design of archaeological sites, as highlighted by the following points:

- Deep understanding of past, current, and future evolutions of the archaeological site for identifying its risks, problems, and opportunities.
- Deep understanding of local socio-economic conditions for the success of the design project.
- Recognition and respect of history, authenticity, local identity, and meanings of cultural heritage for developing proper restoration, exhibitions, and training activities.
- Multifunctionality and flexibility as key actions for hosting a wider range of activities, visitors, and hybrid experiences.
- Improvement of accessibility and mobility connections for attracting a wider community.
- Reuse of abandoned buildings for introducing new imaginative functions.
- Reversibility and recognizability of new additions for preserving and respecting the original fabric.
- Sustainability, energy efficiency, renewable energy sources, and circular economy as fundamental principles for reducing greenhouse gas emissions.
- Green design and biophilia as criteria for boosting the social revitalization of the area.
- Use of digital technologies (e.g., serious games, virtuality, and augmented reality) for preserving and transmitting stories, legends, and intangible heritage.

- Mutual cooperation between local community and public and private sectors for contributing to the revitalization of the neighborhoods.
- Reinvestment of profits for continuative maintenance and management.
- Attractiveness of local craftsmen, creative enterprises, and innovative industries in training, research, and cultural activities on archaeological and natural heritage for creating economic spillovers (i.e., fashion, film production, etc.).
- Creation of employment opportunities in heritage and touristic sectors connected to archaeology (i.e., communication, education, tourism, food production, etc.) and development of cultural activities and events for obtaining economic benefits from visitors and local community.
- Appeal of the new intervention for incrementing local and circular tourism.
- Offering dynamic educational and social activities for residents (not only for tourists).

Fundraising strategies for sponsoring heritage activities.

- Despite these aspects seeming common in a professional architectural design project, they are not usual for high educational design approaches [72]. The students learnt to create complex connections among different disciplinary fields in a critical way, understanding that urban planning and architecture needs a "*living systems approach*" [27] based on a deep knowledge and a positive integration among built, natural, social, and economic systems [26,28]. Some ideas are common to the concept of "*regenerative heritage*", such as improvement of flexibility, hybridization, accessibility, and mobility connections [31]. Others relate to the concept of "*regenerative design*", such as the deep knowledge of heritage, built, and natural systems as well as of socio-economic conditions [25,27]. Other ideas pertain to the concept of "*restorative heritage*", such as the adaptive reuse of heritage, the creation of creative industries, circular tourism, and employments opportunities [30,31]. Finally, other ideas refer to "*biophilia*", such as the use of green design for regenerating a semi-abandoned area [25]. Otherwise, the "*biomimetic approach*" [25,26] was not successful, as students prefer the recognizability of the intervention and the use of digital technologies for creating new experiences and products [33,36]. Furthermore, codesign techniques were fundamental for inspiring new ideas [34,37,38].
- This methodological approach has also several innovative aspects and benefits for the design process, such as:
- Replicability of the workflow both for architectural education and practice.
- Creation of a strategic vision and transparent planning and design process.
- Logical and reasonable scheme and transnational criteria for the sustainable decision-making process.
- Simplification of complex factors facing archaeological sites and local heritage communities today.
- Synthesis and order among environmental, social, and economic information of the site.
- Bridge of traditional boundaries between social, economic, and environmental sciences and between research, practice, and policy.
- Design innovation focused on human needs and participation processes to integrate multiple and future perspectives.
- Reiteration of the evaluations during the design process.

6. Conclusions

The study presents a multicriteria decision analysis workflow for the regenerative design of archaeological sites. This systemic approach aims at creating a positive interaction between built, human, and natural systems, also enhancing heritage and natural environment, human life, social equity, and economic sustainability [20,25]. This method is applied in the Italian UNESCO site of Casterseprio, to verify its feasibility for mapping the interaction between heritage, environmental, social, and economic dynamics in a real case study. The experiment was conducted inside a design studio of the Polytechnic of

Milan to verify the applicability, feasibility, potentiality, and limitation of the workflow in the architectural learning process. This experience provided a positive simulation of the thinking methods that students will encounter in professional life [72–74]. Some differences between traditional and regenerative design processes applied to an archaeological area can be underlined. First, "*traditional design*" is a linear process based on analytical, design, and educational activities, while "*regenerative design*" is a circular process based on a reiterate and dynamic interaction between analytical, design, and educational activities. This requires a continuous design process between teachers, students, and stakeholders, to verify the correctness of the design ideas. The students develop a major consciousness and knowledge about problems, needs, risks, and resources to be applied to the design project. Second, traditional and regenerative design considers heritage and environmental factors, while additionally "*regenerative design*" considers their social and economic interactions. This opens a new dimension for the project design, developing a human-centered approach that aims at involving local stakeholders in the design process through focus groups, interviews, surveys, registration, video production, and other tools normally used in social science. Furthermore, economic factors (not only the cost of the intervention) acquire importance, developing the idea that the architectural design projects on cultural heritage should also provide scenarios for gathering economic benefits for the architectural experience. Third, "*regenerative design*" favors the active collaboration with the stakeholders to boost long-term planning and financial self-sustainability of the interventions. These aspects improve the quality of the teaching, adding new concepts, new disciplinary fields, and a better interaction among teachers, students, and all the stakeholders involved in the codesign process. Moreover, these aspects improve the quality of the design project and of the learning process for the students, adding integrated design ideas and a good understanding of needs and limitations of the archaeological site thanks to the involvement of local stakeholders (e.g., heritage and public authorities, owners, and visitors). Otherwise, limitations concern the small sample size of the students. However, their international backgrounds provide a better understanding of the international mainstream related to design concepts.

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Nomenclature

UNESCO	United Nations Educational, Scientific and Cultural Organization
EU	European
UN	United Nations
SDGs	Sustainable Development Goals
WBDG	Whole Building Design Guide
SWOT	Strengths, Weaknesses, Opportunities, and Threats
IDP	Integrated Design Process
BREAM	Building Research Establishment Environmental Assessment Method
LEED	Leadership in Energy and Environmental Design
GBC	Green Building Council

References

1. A European Green Deal, European Commission. Striving to Be the First Climate-Neutral Continent. Available online: https://ec.europa.eu/info/strategy/priorities-2019-2024/european-green-deal_en (accessed on 18 July 2021).
2. United Nations (UN). *Paris Climate Agreement*; UN: Paris, France, 2015.
3. Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions, A Renovation Wave for Europe: Greening Our Buildings, Creating Jobs, Improving Lives, COM/2020/662 Final. Available online: https://energy.ec.europa.eu/topics/energy-efficiency/energy-efficient-buildings/renovation-wave_en (accessed on 8 February 2023).
4. The European Commission, New European Bauhaus. Available online: https://europa.eu/new-european-bauhaus/index_en (accessed on 2 February 2023).
5. European Parliament. Directive 2010/31/EU of the European Parliament and of the Council of 19 May 2010 on the Energy Performance of Buildings. *Off. J. Eur. Union* **2010**. Available online: https://eur-lex.europa.eu/legal-content/EN/ALL/;ELX_SESSIONID=FZMjThLLzfxmmMCQGp2Y1s2d3TjwtD8QS3pqdkhXZbwqGwlgY9KN!2064651424?uri=CELEX:32010L0031 (accessed on 8 February 2023).
6. European Parliament. Directive 2018/844 of the European Parliament and of the Council of 30 May 2018 amending Directive 2010/31/EU on the Energy Performance of Buildings and Directive 2012/27/EU on Energy Efficiency. *Off. J. Eur. Union* **2018**. Available online: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=uriserv%3AOJ.L_.2018.156.01.0075.01.ENG (accessed on 8 February 2023).
7. European Parliament. Directive (EU) 2018/2002 of the European Parliament and of the Council of 11 December 2018 amending Directive 2012/27/EU on energy efficiency. *Off. J. Eur. Union* **2018**. Available online: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=uriserv:OJ.L_.2018.328.01.0210.01.ENG (accessed on 10 April 2021).
8. European Parliament. Directive 2012/27/EU of the European Parliament and of the Council of 25 October 2012 on energy efficiency, amending Directives 2009/125/EC and 2010/30/EU and repealing Directives 2004/8/EC and 2006/32/EC. *Off. J. Eur. Union* **2018**. Available online: https://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1399375464230&uri=CELEX:32012L0027 (accessed on 8 February 2023).
9. United Nations (UN). The Sustainable Development Agenda. Available online: https:77www.un.org/sustainabledevelopment/development-agenda (accessed on 8 February 2023).
10. ICCROM (International Centre for the Study of Preservation and Restoration of Cultural Property). *A guide to Risk Management of Cultural Heritage*; ICCROM: Sharjah, United Arab Emirates, 2016.
11. New Orleans Charter for the Joint Preservation of Historic Structures and Artefacts. Available online: www.culturalheritage.org (accessed on 8 February 2023).
12. Potts, A. Executive Summary. In *European Cultural Heritage Green Paper Executive Summary*; Europa Nostra: The Hague, The Netherlands; Brussels, Belgium, 2021.
13. United Nations Educational, Scientific and Cultural Organization (UNESCO). *Hangzhou Declaration: Placing Culture at the Heart of Sustainable Development Policies*; UNESCO: Hangzhou, China, 2013.
14. United Nations (UN). Transforming Our World: The 2030 Agenda for Sustainable Development. Available online: https://sustainabledevelopment.un.org/content/documents/21252030%20Agenda%20for%20Sustainable%20Development%20web.pdf (accessed on 8 February 2023).
15. Shetabi, L. *Heritage Conservation and Environmental Sustainability: Revisiting the Evaluation Criteria for Built Heritage, Proceedings of Fabric: The Threats of Conservation*; ICOMOS: Adelaide, Australia, 2015.
16. Serraino, M.; Lucchi, E. Energy Efficiency, Heritage Conservation, and Landscape Integration: The Case Study of the San Martino Castle in Parella (Turin, Italy). *Energy Procedia* **2017**, *133*, 424–434. [CrossRef]
17. Lucchi, E. Multidisciplinary risk-based analysis for supporting the decision-making process on conservation, energy efficiency, and human comfort in museum buildings. *J. Cult. Herit.* **2018**, *22*, 1079–1089. [CrossRef]
18. Rząsa, K.; Ogryzek, M.; Kulawiak, M. Cultural Heritage in Spatial Planning. In Proceedings of the 2016 Baltic Geodetic Congress (Geomatics), Gdansk, Poland, 2–4 June 2016; pp. 85–89.
19. International Council on Monuments and Sites (ICOMOS). *The Paris Declaration on Heritage as a Driver of Development*; ICOMOS: Paris, France, 2011.
20. Mang, P.; Reed, B. Regenerative Development and Design. In *Encyclopedia Sustainability Science & Technology*; Springer: Berlin/Heidelberg, Germany, 2020; Volume 303, p. 2112.
21. Lyle, J.T. *Regenerative Design for Sustainable Development*; John Wiley & Sons: Hoboken, NJ, USA, 1994.
22. Wilson, E.O. *Biophilia*; Harvard University Press: Cambridge, UK, 1984.
23. Reed, B. Shifting from 'sustainability' to regeneration. *Build. Res. Inf.* **2007**, *35–36*, 674–680. [CrossRef]
24. Craft, W.; Ding, L.; Prasad, D.; Partridge, L.; Else, D. Development of a Regenerative Design Model for Building Retrofits. *Procedia Eng.* **2017**, *180*, 658–668. [CrossRef]
25. Naboni, E.; Havinga, L. Regenerative Design in Digital Practice. In *A Handbook for the Built Environment*; Eurac Research: Bolzano, Italy, 2019.
26. Wahl, D.C. Regenerative Design and a Science of Qualities. *Netw. Rev. Sci. Med. Netw.* **2016**, *2*, 12–14.
27. Van der Ryn, S.; Cowan, S. *Ecological Design*; Island Press: Washington, DC, USA, 1996.

28. Sanford, C. *The Responsible Corporation: Reimagining Sustainability and Sustainability and Success*; Josey-Bass: San Francisco, CA, USA, 2011.
29. Cole, R.J. Transitioning from green to regenerative design. *Build. Res. Inf.* **2012**, *40*, 39–53. [CrossRef]
30. Hölscher, K.; Wittmayer, J.M.; Loorbach, D. Transition versus transformation: What's the difference? *Environ. Innov. Soc. Transit.* **2018**, *27*, 1–3. [CrossRef]
31. Luca, E.; Sulc, I.; Haselsteiner, E. Regenerative Heritage. Available online: www.eurestore.eu (accessed on 10 April 2021).
32. Issa, T.; Isaias, P. *Sustainable Design*; Springer: New York, NY, USA, 2022.
33. Elabd, N.M.; Mansour, Y.M.; Khodier, L.M. Utilizing innovative technologies to achieve resilience in heritage buildings preservation. *Dev. Built Environ.* **2021**, *8*, 100058. [CrossRef]
34. Ferretti, V.; Gandino, E. Co-designing the solution space for rural regeneration in a new World Heritage site: A Choice Experiments approach. *Eur. J. Oper. Res.* **2018**, *268*, 1077–1091. [CrossRef]
35. Aksamija, A. Regenerative Design of Existing Buildings for Net-Zero Energy Use. *Procedia Eng.* **2015**, *118*, 72–80. [CrossRef]
36. Naboni, E.; Natanian, J.; Brizzi, G.; Florio, P.; Chokhachian, A.; Galanos, T.; Rastogi, P. A digital workflow to quantify regenerative urban design in the context of a changing climate. *Renew. Sustain. Energy Rev.* **2019**, *113*, 109255. [CrossRef]
37. Yani Said, S.; Aksah, H.; Dewiyana Ismail, E. Heritage Conservation and Regeneration of Historic Areas in Malaysia. *Procedia–Soc. Behav. Sci.* **2013**, *105*, 418–428. [CrossRef]
38. Trillo, C.; Petti, L. A novel paradigm to achieve sustainable regeneration in Historical Centres with Cultural Heritage. *Procedia–Soc. Behav. Sci.* **2016**, *223*, 693–697.
39. United Nations Educational Scientific and Cultural Organization (UNESCO). What Is Meant by "Cultural Heritage"? 2020. Available online: http://www.unesco.org/new/en/culture/themes/illicit-trafficking-of-cultural-property/unesco-database-of-national-cultural-heritage-laws/frequently-asked-questions/definition-of-the-cultural-heritage (accessed on 8 February 2023).
40. United Nations Educational Scientific and Cultural Organization (UNESCO). *Convention Concerning the Protection of the World Cultural and Natural Heritage*; UNESCO: Paris, France, 1972.
41. United Nations Educational Scientific and Cultural Organization (UNESCO). Database of National Cultural Heritage Laws. 2009. Available online: https://en.unesco.org/cultnatlaws (accessed on 8 February 2023).
42. Teutonico, J.M.; Palumbo, G. *Management Planning for Archeological Sites*; Getty Conservation Institute: Los Angeles, CA, USA, 2002.
43. Vecco, M. A definition of cultural heritage: From the tangible to the intangible. *J. Cult. Herit.* **2010**, *11*, 321–324. [CrossRef]
44. Lucchi, E. Review of preventive conservation in museum buildings. *J. Cult. Herit.* **2018**, *29*, 180–183. [CrossRef]
45. Tejedor, B.; Lucchi, E.; Bienvenido-Huertas, D.; Nardi, I. Non-Destructive Techniques (NDT) for the diagnosis of heritage buildings: Traditional procedures and futures perspectives. *Energy Build.* **2022**, *263*, 112029. [CrossRef]
46. ICOM (International Council of Museums). *ICOM Statutes*; ICOM: Vienna, Austria, 2007.
47. Laing, R. Built heritage modelling and visualization: The potential to engage with issues of heritage value and wider participation. *Dev. Built Environ.* **2020**, *4*, 100017. [CrossRef]
48. Orbey, B.; Sarıoğlu Erdoğdu, G.P. Design process re-visited in the first year design studio: Between intuition and reasoning. *Int. J. Technol. Des. Educ.* **2020**, *31*, 771–795. [CrossRef]
49. Schon, D.A. *Educating the Reflective Practitioner. Toward a New Design for Teaching and Learning in the Professions*; Jossey-Bass Publishers: Hoboken, NJ, USA, 1987.
50. Whole Building Design Guide (WBDG). WDBG Historic Preservation Subcommittee. Available online: www.wdbg.org (accessed on 8 February 2023).
51. Lucchi, E.; Delera, A. Enhancing the Historic Public Social Housing through a User-Centered Design-Driven Approach. *Buildings* **2020**, *10*, 159. [CrossRef]
52. Krueger, A.E.; Pollmann, K.; Fronemann, N.; Foucault, B. Guided User Research Methods for Experience Design. A New Approach to Focus Groups and Cultural Probes. *Multimodal Technol. Interact.* **2020**, *4*, 43. [CrossRef]
53. Holtzblatt, K.; Wendell, J.B.; Wood, S. *Rapid Contextual Design: A How-to Guide to Key Techniques for User-Centered Design, The Morgan Kaufmann Series in Interactive Technologies*; Elsevier: Amsterdam, The Netherlands; Morgan Kaufmann: San Francisco, CA, USA, 2005.
54. Hassenzahl, M. Experience design: Technology for all the right reasons. *Synth. Lect. Hum. Centered Inform.* **2010**, *3*, 1–95.
55. European Commission. In-Depth Report: Indicators for Sustainable Cities. *Sci. Environ. Policy* **2015**, *22*. [CrossRef]
56. Karol, E.; Brunner, J. Tools for Measuring Progress Towards Sustainable Neighborhood Environments. *J. Sustain.* **2009**, *1*, 612–627. [CrossRef]
57. Pintér, L.; Hardi, P.; Martinuzzi, A.; Hall, J. Bellagio STAMP: Principles for Sustainability Assessment & Measurement. *J. Ecol. Indic.* **2012**, *17*, 20–28.
58. Harsimran, K.; Pushplata, G. Urban sustainability assessment tools: A review. *J. Clean. Prod.* **2019**, *210*, 146–158. [CrossRef]
59. Sharifi, A.; Murayama, A. A critical review of seven selected neighborhood sustainability assessment tools. *Environ. Impact Assess. Rev.* **2013**, *38*, 73–87. [CrossRef]
60. Building Research Establishment (BRE). BREAM®Communities. Available online: https://www.breeam.com/discover/technical-standards/communities (accessed on 8 February 2023).

61. Building Research Establishment (BRE). BREAM®Wiki. Available online: https://www.designingbuildings.co.uk/BREEAM_Wiki (accessed on 8 February 2023).
62. Building Research Establishment (BRE). *BREEAM®Communities Technical Manual*; BRE: Bricket Wood, UK, 2017.
63. Borges, L.A.; Hammami, F.; Wangel, J. Reviewing Neighborhood Sustainability Assessment Tools through Critical Heritage Studies. *Sustainability* **2020**, *12*, 1605. [CrossRef]
64. Lucchi, E.; Buda, A. Urban green rating systems: Insights for balancing sustainable principles and heritage conservation for neighbourhood and cities renovation planning. *Renew. Sustain. Energy Rev.* **2022**, *161*, 112324. [CrossRef]
65. U.S. Green Building Council (GBC). Available online: www.usgbc.org (accessed on 8 February 2023).
66. Green Building Council (GBC) Italia. Available online: www.gbcitalia.org (accessed on 8 February 2023).
67. Hettithanthri, U.; Hansen, P. Design studio practice in the context of architectural education: A narrative literature review. *Int. J. Technol. Des. Educ.* **2021**, *32*, 2343–2364. [CrossRef]
68. Park, S. Rethinking design studios as an integrative multi-layered collaboration environment. *J. Urban Des.* **2020**, *25*, 523–550. [CrossRef]
69. *Standard EN 16883:2017*; Conservation of Cultural Heritage. Guidelines for Improving the Energy Performance of Historic Buildings; Comitè Européen de Normalization (CEN): Bruxelles, Belgium, 2017.
70. Lucchi, E.; Baiani, S.; Altamura, P. Design criteria for the integration of active solar technologies in the historic built environment: Taxonomy of international recommendations. *Energy Build.* **2023**, *278*, 112651. [CrossRef]
71. Lucchi, E. Integration between photovoltaic systems and cultural heritage: A socio-technical comparison of international policies, design criteria, applications, and innovation developments. *Energy Policy* **2022**, *171*, 112203. [CrossRef]
72. Cho, J.Y. An investigation of design studio performance in relation to creativity, spatial ability, and visual cognitive style. *Think. Ski. Creat.* **2017**, *23*, 67–78. [CrossRef]
73. Djabarouti, J.; O'Flaherty, C. Experiential learning with building craft in the architectural design studio: A pilot study exploring its implications for built heritage in the UK. *Think. Ski. Creat.* **2019**, *32*, 102–113. [CrossRef]
74. Grover, R.; Emmitt, S.; Copping, A. Critical learning for sustainable architecture: Opportunities for design studio pedagogy. *Sustain. Cities Soc.* **2020**, *53*, 101876. [CrossRef]