ENVIRONMENTAL SCIENCE LAB PLANNING AND CONSTRUCTION AS AN INTERNATIONAL DESIGN-BUILD STUDIO: TEACHING AND LEARNING EXPERIENCE

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This working paper explores experiential learning and teaching experiences that aim to create socially responsible architects and buildings who prioritize sustainability and innovation and offer some questions for further research. The ideas presented in this work are the evaluation of a cross-cultural Design-Build studio established in 2022 by design units from universities in Ecuador, Chile, and Germany to reflect on various aspects of architectural design, civil engineering, management, and other aspects of sustainable construction that are often overlooked in traditional teaching programs. The Design-Build methodology explores such potential linkages: 1- Interactive and dynamic learning environment allow to establish the design of an architectural project through a cooperative process, 2- The application through scientific inquiry and critical thinking of local construction techniques in international projects update the methods to comply with current building codes, and 3- Active involvement of the team planning in the construction of the building, allow to test and establish sustainable constructions methods that are suitable for informal self-build and can be reproduced by the local population. Over one hundred participants contributed to the completion of the building. A questionnaire was conducted to evaluate the academic experience. Most respondents reported an increase in their academic and practical knowledge in construction, as well as in architectural skills, self-confidence and personal skills.

Keywords: Architecture students, Ecuador, Sustainability, Do-it-yourself construction.

1 INTRODUCTION

Architectural design units from universities in Ecuador, Chile, and Germany established a Design-Build studio in 2022 to reflect on various aspects of the design process and prove how experiential learning can create socially responsible architects who prioritize sustainability and innovation. The aim was to design and construct an "Environmental science lab” on the campus of PUCE-SI in
Ibarra, Ecuador, under sustainable and inclusive aspects, and make it available for secondary and primary school students and local community as a practical model to be imitated.

This working paper summarizes the process and evaluates how the program improves the knowledge and skills of the participants. The Design-Build studio was intentionally created to expose the participants to the realities of architectural design, civil engineering, management, and other aspects of sustainable construction that are often overlooked in traditional teaching programs and delineates ideas and questions that seek informing further investigations and research agendas.

At the same time, the program aims to demonstrate methods for developing informal construction in the Global South in a climate-adapted way. The project is an inter-institutional research network and implementation project in the field of design and building science with the objective of improving innovation in sustainability by the identification, formulation and dissemination of small-scale, climate-positive design and construction methods that contribute to the sustainable development of tomorrow’s urban and rural structures, especially in line with traditional more climate-adapted building methods that are suitable for informal self-construction. Cross-cultural work groups, collaborative online platforms, prototyping, and real-size tracing of architectural plans enabled over seventy students and ten teachers to develop and agree on a specific project. They were able to transcend cultural and linguistic barriers and achieve a collective vision.

2 PROJECT PROPOSAL

The academic process was named “Think, Design, Build workshop”, and took place in over 16 months of collaboration between two Ecuadorian universities, two German universities, and one Chilean university, it arose from the concern about how to ensure a collaborative academic exercise of international scope involving different architecture schools, and it was linked to real societal issues aiming to use traditional and sustainable construction techniques, making a contribution to the environment and to the community.

As it was a project based on real needs, in this case, creating a learning space for students from rural public schools, enabling them to complement their studies with equipment and tools currently unavailable in their places of study, such as laboratories and spaces for digital technologies. The host university, PUCE-SI, planned to utilize this space for one of its outreach programs, destined to provide an educational space for secondary rural students. Therefore, the work focused on how to bring construction tradition to sustainability by merging traditional construction knowledge and methods with modern practices and sustainable technologies to create a structure that is environmentally friendly, promotes energy efficiency, and saves resources. The initial hypothesis was that firsthand construction work reinforces academic knowledge and practical construction skills, also contributing to improving personal skills as intercultural collaboration.

The site was established in the center of farmland managed by the agricultural and environmental sciences school within the PUCE-SI campus in Ibarra. The project was mainly financed by this institution. The support infrastructure provided by the university consisted in a carpentry and ironwork workshop and a construction office, both near the site, as well as materials and resources which was also contributed by some companies and institutions. The architectural project was developed by seventy architecture students under the supervision of ten university professors. The engineering aspects were supervised and resolved in collaboration with external engineers and professors from the PUCE-SI. The workforce would consist of the same architecture students and professors, both local and foreign, who could travel to the site, and local skilled laborers who would guide the work and share their knowledge.
With this background, both spatial and constructive solutions needed to be innovative, as they had to overcome the banal aspects and focus on construction techniques, efficient resource use, and maximum utilization of the limited available resources.

This project was conceived as a proposal that, from the outset, considered the integration of needs, site conditions, climate, topography, and the available techniques and materials in the area. Furthermore, it was crucial to acknowledge that the same architecture students involved in the design would be responsible for the on-site execution, resulting in a sensitive approach to materials, customs, and traditional construction techniques.

3 DESIGN BUILD AS TEACHING METHODOLOGY

This project was conceived from its origin under a teaching-learning methodology called “Design-Build”. The term originally described the process of realizing a building, from design to the execution, from a single source (Design Build Institute of America 2018). In the academic context of architectural education, the term has established itself as an alternative form of teaching and learning. It combines a marked social commitment with professional - theoretical and practical - learning, thereby bringing together teaching, research and practice in the complexity of a real project (Fattinger 2011).

The model “Service Learning” (learning through engagement) combines subject-specific learning in the classroom with social engagement. Within the framework of a course, the theoretical foundations of a topic are scientifically prepared and the experiences from the "engagement phase" are reflected upon and summarized. Students apply what they have learned in practical projects with partners from the non-profit sector. However, the Design-Build methodology extends the “Service Learning” model through the complexity and intensity of a construction task in an international context. Design-Build as a form of teaching shows a long tradition in architectural education in the USA but was not so widespread in Europe until a few decades ago. Although this methodology was part of experiences at the beginning of the past century, such as the Bauhaus, it is in recent decades that it has gained ground again given its obvious advantages (Guarrotxena 2022). In the meantime, there is an international platform that collects examples from all over the world (European DesignbuildXchange Platform 2023).

The aim is to use the potential of interdisciplinary and intercultural cooperation to realize a design task with a strong innovative character. Students are given the opportunity to experience a construction task from the preliminary research and design to implementation on site. With this, they learn to autonomously develop financing concepts, to assume logistical tasks and engage in exchanges with the different agents involved in the complete project process too. They acquire, in addition to architecture-specific qualifications, extra- and supra-disciplinary qualifications through intercultural and interdisciplinary work. In addition to specialized skills, the concepts of identity and social responsibility should also be promoted. Students were asked about these qualifications in a survey.

DB projects, thus, respond to the increasing demand in architectural education to expand conceptual ideas of academic design exercises into practice (Pawlicki 2020). Instead of a self-sufficient objectness, the development process plays a key role. They also show the potential of interdisciplinary and international cooperation to meet the challenges of globalization, climate, and demographic change with regionally innovative solutions (Valdivia 2018). The projects are supposed to show what can happen with personal initiative and encourage others to do the same – it is also meant to attract potential support from the private sector and additional involvement from foundations (Sto-Stiftung 2017). The tried and tested models of cooperation between university and non-university institutions, private individuals, NGOs, and foundations, show that actual
student tasks beyond fictitious academic assignments lead to successful, real projects. They also complement the traditional didactic-scientific formats and forms a fruitful framework for the successful implementation of projects of a marked experimental, sustainable and social nature (Pasel et al. 2018).

4 CASE STUDY: THE ENVIRONMENTAL SCIENCE LAB

The cooperative design process considered an open matrix to reconcile the group of students, their interests and learning, covering a total of four stages as part of the development process: A first exploratory stage with preliminary proposals by teams from each University, a second stage developed by mixed teams of students from different universities generating proposals with strong ideas in the style of 'Stick and Stones'. A third stage, in which three proposals with clear concepts to be developed by all teams were selected. And, a final stage, which considered developing these three prototypes based on a set of components that would allow the re-mixed teams to explore both the constructive and spatial possibilities of the enclosures, the structure and roof, the furniture, the natural lighting and the location.

The “Environmental Science Lab” had to be conceived as a prototype of a generic typology for future social projects in Ecuador, therefore, the flexible plant and design parameters based on components took precedence in the final phase of the project, with the objective of allowing its adaptation to different uses. Depending on the objectives, the "Learning Pavilion" typology can be used as a classroom, workshop, cafeteria, games room or laboratory and thus used in other places or for other social projects. From there, constructive solutions and procedures for sustainable alternatives were developed, which were then designed and simulated by architecture students from all participating universities, as well as built as a 1:1 prototype. Particular attention was paid to teaching of local traditional construction techniques, which were jointly applied and examined with respect to their transferability to contemporary construction projects.

The final proposal for the prototype building consisted of a pavilion that offers excellent protection against overheating from solar radiation while making the best possible use of daylight. The main structure was constructed with wooden pillars and beams, while the interior partition and service modules were made with rammed earth walls, earth blocks and rammed earth. The roof was resolved with a recycled lightweight metal roof and the exterior enclosure was made with glass and metal profiles. The observation tower, which appears as a vertical block, was made entirely of wood.

5 CONSTRUCTION PROCESS

The construction process had to be executed in a short period so that all students could learning the largest possible number of different works from the entire construction process during their stay on site. The core period of the construction site was only six months from February 2023. The prefabrication of elements made it possible to optimize the time schedule and carry out key work steps in the workshops. Accurate detailed planning and proactive coordination between the planning teams were required to enable precise prefabrication in the workshop. Due to the simultaneous works almost all work steps could be carried out during the stay of the student teams, which facilitated a technical exchange and seamless continuation of the work.

136 students from all participating universities took part in this process with different periods of attendance. In addition to the students, there were twelve teachers actively participating, and two experienced construction workers were also hired to assist and teach about completing complex construction tasks.
The construction process could be divided into six main phases in which all participants were involved at all stages and played key roles in both construction and management: While the (1) foundation work phase was the most physically demanding of all (as it involved excavating the ground, moving and laying stone and gravel, bending rebar and pouring concrete), with the largest number of students on site at the same time, the modular design of the building allowed for simultaneous work in different trades: (2) The earthen walls included two construction methods: adobe brick and rammed earth, (3) composite pillars and roof beams of the wooden structure were pre-cut in the workshop so that they only had to be positioned and assembled on site, (4) the roofing system from residual items include an organic insulation layer made of rice straw and (5) the window enclosures were prefabricated in the iron workshop using self-made steel frames. Finally (6) the finishings all surfaces were treated, painted or polished, water and sewage piping and a solar energy system was built.

In each step the students were instructed in the use of diverse tools and supervised by teachers and hired construction workers. However, most of the work was carried out by students who had little or no previous craft experience. Continuous planning work accompanied the construction work: Details had to be redesigned and adapted according to the availability of materials and implemented directly on the construction site. The communication between the participants required a particular openness to different construction cultures at the construction site. The joint work enabled a new perspective on the unfamiliar.

6 SURVEY RESULTS

In an exploratory survey applied to participants (n=35), 78.6% reported that they had intermediate, low or very low academic knowledge about construction, and 75.8% reported that they had intermediate, low or very low practical construction skills, before participating in this experience, meaning that the large majority of students perceived they lacked, to a considerable extent, construction knowledge and practical skills. On the other hand, when asked about how much these two aspects had improved after being part of the Design-Build activities, 85.3% of students said their academic knowledge was better or a lot better than before, and 91.7% said that their practical skills were better or a lot better after participating in the construction stage.

As for other contributions on student abilities, 72.8% of the students reported that their ability to work with international groups had improved somewhat or a lot, 84.9% considered that this experience had helped them improve their architectural design skills to a high or very high extent, 73.5% said that they now feel more confident getting involved in construction activities, and 91.2% said that this project helped them value traditional or vernacular construction techniques more. When asked if they felt that any of their personal skills had improved, the most common responses were patience (82.4%), problem solving (79.4%), decision making (70.6%), sociability (70.6%), and self-confidence (70.6%).

In general terms, 82.4% of students valued their experience as good or exceptionally good and 93.9% considered that these activities should be included in the regular training of an architecture student. These results of students' perceptions of their own participation in this project show that it can be a fundamental contribution to the academic and professional skills of future architects, allowing them to improve their knowledge and practical abilities in construction and design. It also provides them with key personal and professional tools that are necessary for succeeding in international collaborations and engaging in challenging real life construction projects.

This academic experience has proven to be valuable for students who reported a notorious improvement in their academic knowledge regarding construction and architectural design. It also helped participants develop further complimentary skills such as international group collaboration,
while creating a better perception and higher interest in traditional and more sustainable construction methods. The improvement of practical construction skills was also highly valued by students, who reported to have gained abilities they did not have and felt more confident on engaging in future construction projects. Additionally, the participation in this workshop offered students the opportunity to better relevant social skills such as patience, problem solving or decision making. Last but not least, one of the most important success experiences of the entire academic project was not only the technically successful completion of the building, but also the high quality of the finished architecture.

7 CONCLUSIONS

The experience conducted during the planning and execution of the project highlights the importance of including this type of Design-Build studios in the university curricula of the faculties of architecture as a key element in the practical learning process of the students. In addition, having the possibility of applying traditional construction techniques allows for sensitization to the environment and resources, making the proposal a tailor-made fit, where the constructive detail plays a fundamental role, getting students to approach the smallest scale of construction.

In addition, Design-Build projects are particularly significant as role models. A relevant proportion of buildings in the Global South are built informally by the users themselves. These buildings are not subject to institutional control and professional design. The predicted rapid urbanization and economic development in these regions will drastically increase the demand for new buildings. Accordingly, the informal construction sector plays a significant role in the emission of greenhouse gases, as the Eurocentric models of building with reinforced concrete structures are also applied here. A key objective of the sustainability strategy of the DB project is to test and establish sustainable construction methods that are suitable for informal self-build and can be reproduced by the local population. Sustainable traditional construction methods that have always been used in self-build are used. The rediscovery of these structures, which have been historically and systematically neglected by the Eurocentric perspective, also represents a research gap for European partners; these structures not only anticipate the paradigm shift to the so-called "post-fossil city" but can also help shape it.

References