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Learning by doing: building with earth at the Universidad Peruana de Ciencias Aplicadas

Building with earth is an essential and initial part of the training of architecture students at the Universidad Peruana de Ciencias Aplicadas (UPC). The university and its professors are committed to using earth and natural materials as primary raw components in the building process. The study course "Preliminary Work", the first of the construction branch at this university's Faculty of Architecture, covers building techniques with different sorts of earth that have been used in Peru throughout history until today.

Different teaching methodologies of an active and experimental character are employed in parallel from beginning to end of the semester and work in combination to provide the student with a profound knowledge of the subject: "Theory, design and construction".

Over the past 15 years, our teaching methods for this subject have evolved to improve the students' knowledge acquisition and to address the following questions:

- Is there a way to facilitate the students' learning of the building process?
- Is there a methodology that can be applied to improve the teaching of the building process with earth?
- Where does the "doing" take place in this methodology?
- What impact does the subject have on students graduating from the Universidad Peruana de Ciencias Aplicadas?

In this article we present the methodology used in the classes of the "Preliminary Work" course at UPC's Faculty of Architecture, and the specific resources developed to facilitate student learning at different stages of knowledge acquisition. One of the most important stages is the execution of an architecture model with earth, using their own hands.

Context

Peru and its legacy

In Peru's territory, we can find a vast number of monuments and archeological constructions related to earth building. Ancestral cultures such as the "Mochica" and "Chimu" in the north of Peru developed beautiful and complex structures. For example,

Fig. 1 Chan Chan, Trujillo, Peru, 2015

Fig. 2 Pachacamac, Lima, Peru, 2016

Fig. 3 The Torre Tagle Palace, Lima, Peru, 2013

Fig. 4 Rural building, Cabanaconde, Arequipa, Peru, 2014

"Chan Chan" (Figure 1) is one of the biggest prehispanic cities built with earth, and has been accorded the status of a UNESCO World Heritage. Other examples include the historic old town of Lima, and the archaeological complex of Pachacamac (Figure 2).

Traditions related to building with earth are present in the cultural heritage of most of Peru's population, being transmitted from generation to generation. This ensures the continuity of working with the material, and reaffirms its role as part of local culture.

Economic conditions

According to data from the Peruvian National Institute of Statistics and IT (Instituto Nacional de Estadística e Informática – INEI, 2013), 28.6 % of the Peruvian population lives in poverty or extreme poverty. They also found that 35.4 % of the houses in Peru were predominantly built using adobe, tapial (rammed earth) and quincha (wattle and daub), of which 22.6 % are located in urban areas (Figure 3) and 74.1 % in rural areas (Figure 4).

Although this data dates back to a report from 2013, it is fair to say that around one third of the Peruvian population lives in poverty or extreme poverty, and more than one third of the population lives in houses built with earth. This certainly reflects how important it is that professionals involved in construction know the technologies that utilise earth as building material, and consider earth building as a more affordable alternative.

Seismic conditions

The Peruvian territory is located in a high-risk seismic zone; according to the Peruvian institute of Geophysics (Instituto Geofisico del Peru – IGP), there have been 204 seismic waves (tremors) in the first six months of 2016. The last significant seismic wave was in August 2007, in the South of Peru. This earthquake registered 7.9 on the Richter magnitude scale, caused 513 deaths and 2,291 injuries, destroyed and damaged 76,000 houses, and affected 431,000 people.

This is why construction with earth in Peru has to improve the reinforcement of building structures to prevent buildings collapsing in the event of an earthquake. It is important to point out that the country has a new technical standard: NTE 0.80 Adobe, which has the goal of regulating the design of low-cost and public interest buildings in order to make them more resistant to seismic activity.

The Universidad Peruana de Ciencias Aplicadas

The Universidad Peruana de Ciencias Aplicadas (UPC) was founded in Lima in 1994, and has the mission to "educate innovative leaders with a global vision to transform the country" and the vision to "be a leader in higher education with excellent academic and innovative capacity". In 2004, UPC became part of the Laureate International Universities network. In July 2016, it also obtained international accreditation by the WASC Senior College and University Commission, one of the most important regional accreditation institutions in the United States.

UPC's educational model is based on five fundamental principles: competency-based learning, student-centred learning, reflective and autonomous learning, diversity with global vision, and learning about sustainability. These pillars facilitate the development of a comprehensive education that encompasses all dimensions of the human being: knowing, knowing how to do, and knowing how to be.

Fig. 5 Theory class, 2016

Fig. 6 Practical session on soils, 2016

The Faculty of Architecture was one of the first faculties at the UPC and it included a mandatory course in their curriculum that trains future professionals in the art of building with earth. This course has been part of the curriculum for over 20 years, and has helped students understand their culture better and to meet people's needs regarding sustainability.

Learning methodology

The "Preliminary Works" subject is the means by which students begin the process of acquiring knowledge of construction at UPC's Faculty of Architecture. It does so through experiential learning, using a methodology with active and experimental components, and by seeking to develop general quantitative reasoning[1].

The course lasts 16 weeks and is divided into two parts: the first is primarily theoretical to teach students the basics, enabling them to start their own design projects with earth, while the second is purely practical and hands-on, in which the students use their theoretical knowledge for the execution of a project.

The course covers the following modules:
1. Architecture, environment and sustainability,
2. Analysis of soils and building systems with soil,
3. The design and construction of a building.

In the first module, students develop awareness of the importance of building with earth in the present day: as a cultural legacy, as an affordable alternative and as a sustainable method.

In the second module, students learn the characteristics of the materials and its seismic-resistant properties as well as the construction techniques used in earth building in Peru.

In the third module, students then apply their recently acquired knowledge by designing and constructing a demonstration model.

The structure of the course is shown in Table 1.

Table 1 Course structure

Module 1
Sustainable architecture
Background of building with earth
Module 2
Soil analysis
Structural behaviour of buildings with earth
Construction systems with earth
— Cane-reinforced adobe
— Plastic-mesh-reinforced adobe
— Wire-mesh-reinforced adobe
— Tapial (rammed earth)
— Quincha (wattle and daub)
Module 3
Preliminary project
Practical construction sessions
Building design

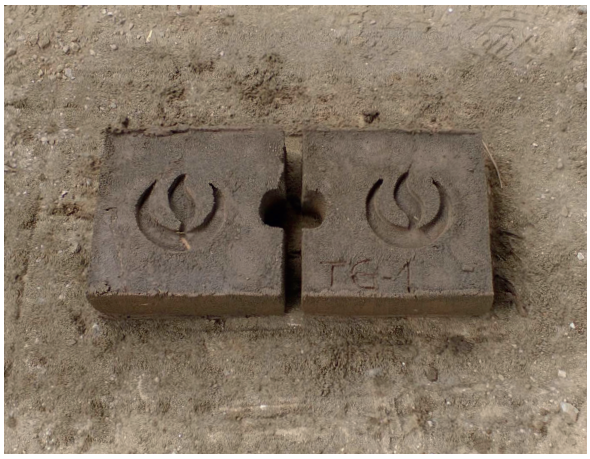

Fig. 7 Adobe blocks made by the students, 2016

Fig. 8 Evaluation of the design plans, 2016

This methodology revolves around three pillars: theory, design and construction, which are put in practice throughout the course in order to maximise meaningful learning.

The course is carried out in student workgroups, with twenty students divided into four groups. Every group is given an earth building system, and they are expected to develop different academic assignments around it, such as a construction detail model, a design project and a final presentation.

The course starts by asking each group to investigate their assigned building system. It is in this first phase that questions arise before the formal explanation of the modules. The course lectures (Figure 5) then begin and are completed by practical assignments such as soil surveying (Figure 6), the manufacture of adobes (Figure 7), modelling, levelling, tracing and staking out. During these first weeks, the groups start designing the project (Figure 8) and building their model of construction details (Figure 9).

At the half-way point of the course, the students have internalised the comprehensive theory, have undertaken field work, and have faced the challenge of designing a project with earth building technology and developed ways to solve the most important construction details.

The second part of the course does not take place in the classroom, where theory is taught. Instead, construction workshops take place in a space that is equipped with the tools and necessary materials for the execution of a demonstration model (Figure 10). Their performance is also measured based on group-based activities, in which every group has a specific task per session. These tasks rotate throughout the sessions with different construction systems. To efficiently carry out this part of the course, students require the support of qualified supervisors and the instruction of teachers who can model how each task should be performed.

During these weeks, the professors continue reviewing the project's design and the detailed model, leading up to a final presentation in which the students present their results for each of the academic tasks in front of their classmates. To wrap up the course, students formally present the demonstration models that they built with their own hands in an event attended by leading academic authorities from the Architecture Faculty, family and friends (Figure 11).

It is difficult to understand and internalise construction concepts through theory in the classroom alone, which is why this method was proposed to facilitate and enhance the acquisition of knowledge with "doing". Not only does "doing" take place in the second half of the course when the demonstration model is built, but also in the first part when they start to develop the model and design a sustainable housing project. Consequently, students learn themselves how to resolve the difficulties that arise in practice by "doing".

From our experience, we can confirm that there is an applicable methodology in earth building education that facilitates the skills acquisition of students and makes "doing" a core aspect of student learning.

In an effort to further improve our methodology, we recently conducted several surveys among the alum-

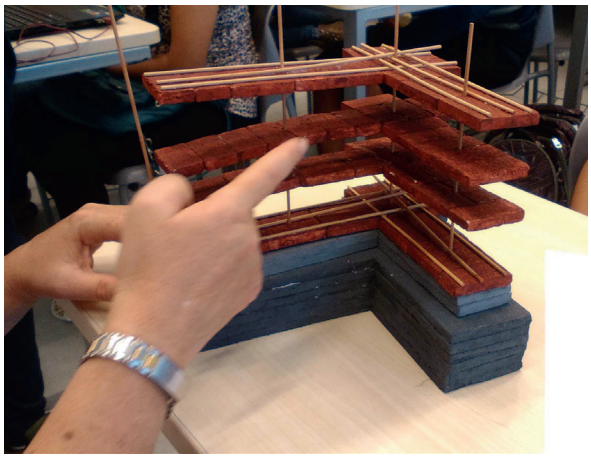

Fig. 9 Evaluation of a detail model, 2016

Fig. 10 Students in the practice session, 2016

ni of the Faculty of Architecture and among the students of the course at the end of the semester.

The data collected reveals that most students value this experience very highly and are aware of the unique opportunity to build something with their own hands. From all respondents, almost 80% believe that this subject is important in their formation as professionals, and over 60% think that having studied the different technologies of building with earth contributed to their understanding and appreciation of their cultural heritage, and mention that this was their first contact with natural materials and sustainable architecture.

Conclusions

Since its foundation, the Universidad Peruana de Ciencias Aplicadas has acknowledged that having knowledge and working experience of the tools used in the construction processes is essential to the training of architects. Experiential knowledge of what construction means is pivotal for the professional future of graduates, enabling them to properly lead the building process.

The "learning by doing" teaching methodology has evolved and been refined over time, including the educational resources such as making models of construction details and developing research and design projects.

Fig. 11 Final presentation, 2015

The method outlined above will help us identify how students are internalising knowledge, and is not only in line with the educational model of skills acquisition, but also contributes to other pillars of educational learning that promote autonomy, trust and constructive intuition. It also fosters respect among students for their heritage and raises awareness for making the world more sustainable.

Footnote

1 Ability to interpret, represent, communicate and use different types of quantitative information in real-world situations. It also includes the ability to calculate, to reason, and to make judgements and decisions based on quantitative information

All photos by María del Rosario Velasco García.

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