Generation of architectural designs using soundscapes: an educational case study

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Abstract

Architectural design process contains a crucial stage called "insight", in which the vital creative phase of the design process begins. Additionally, "design fixation", or simply designing from external stimuli, has been one of the most common methods to approach this phase. Sound as external stimuli for designing, has been used in many historical cases. However, it has never been considered as a design engine for inhabited interior environments. For this reason, some experiments were conducted, designing from a soundscape. This paper will present an educational experience at Barcelona School of Architecture in UPC and at the Faculty of Architecture in RWTH Aachen University, among others. The main features –such as active learning process, project-based workshop or decodification of spatial perception- will be highlighted.

Introduction

Sometimes acousticians work with architects. This happens especially in those projects in which distribution, diffusion and perception of sound is strongly dependent on the built environment. In those cases, an understanding of the impact of the architect's design decisions on the sound field propagation is needed for the collaborative work between both professionals. For that purpose, an educational approach to architectural acoustics is useful for architects. This paper collects some of the architectural acoustic educational case studies done by some of the authors (in collaboration with different institutions).

In addition, this paper is in tune with other experiences presented by some of the authors in [1], in which they pointed out and evaluated an acoustic educational experience for architects and building engineers. There, the study recorded a good acceptance of the project-based experience in the field of room and building acoustics learning from the students.

The final goal in all these educational experiences is to awaken awareness of the impact of the design decisions on the sound field. For this purpose, the experiences have been divided in two approaches, thus emphasizing two main aspects of the problem: the teaching of acoustic concepts and the role of sound in the creative phase of the architectural design process. The first approach has been tested in different studies: recording good acceptance of project-based experiences in the field of room and building acoustics learning from students [1]; introducing sound in urban space representation [2]; and evaluating the qualitative and quantitative aspects from the student's side [3]. The second approach was initiated in the previous version of the experience here presented: soundscape as a design engine for inhabited interior environments [4].

The present paper will report the last educational experiences framed in the second approach, thus emphasizing the generation capacities of soundscapes for architectural dwelling designs. In this context, it is necessary to understand the basic flow of architectural design process and detect the phase in which the introduction of sound concepts will impact further acoustic architectural awareness and further design developments.

Architectural design process

Gilbert Herbert defines the architectural design process as the consecutive process five phases which can be recurrent or finally culminate in the executive project and the construction of the building [5]. Herbert defines five stages comprising the architectural design process: problem, programme, insight, hypothesis and verification.

Image 1: Gilbert Herbert´s architectural design process description [5].

The central phase of such process, the so-called "insight" phase, describes the beginning of the creative input for the architectural project. In this phase, the problem (derived from the site, the client, or other necessities) has derived to a programme (which includes what the future building will have to present in order to solve the problem, in terms of number of rooms, square meters or connections between rooms, among others). However, the solution for the presented problem, together with the programme required, will have different final built solutions depending on the architect who will design the final proposal. The diversity of solutions starts in the "insight" phase of the architectural design process. There, every architect stablish their core idea willing to sustain the most of the design decisions in the architectural project.

Sound as a core idea generator for architecture projects is tested in the experiments presented here. This approach differs from other common practices considering light, geometry, visuals or terrain features as input for the "insight" phase.

Methodology, participants and results of the tests A, B, and others

Test A and B

The main task of these tests consists of the following: the student can hear of a soundscape with no visual information of the environment it belongs to; based on that, the student

draws the architectural environment is perceiving from the soundscape, and generates an architectural proposal. Before the main task is requested to the students, an example is presented: a different soundscape with different architectural designs serves as examples of the task to do. This procedure follows the "design fixation" methodology [6] usually used in the instructive process of architects. The task for students included a pre and post questionnaire for subjective preferences.

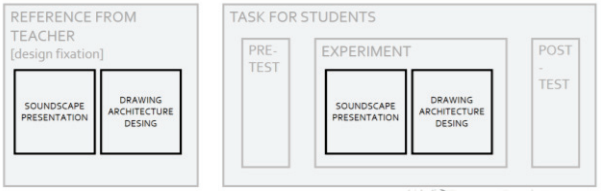

Image 2: Diagram flow for the test A and B.

Test A was performed at the School of Architecture of Barcelona (ETSAB), from the Polytechnic University of Catalunya (UPC). It included 52 architecture students, expert subjects, between the ages of 19 and 22. The experiment setup was set in one of the architecture workshop rooms at the ETSAB, supported by a stereo sound reproduction system (a pair of 100W loudspeakers in the ceiling). The results of this test consisted of individual plan and section sketches made by hand, 3D isometries sketched by hand, pre and post questionnaires and rendered images for material definition and final overview of the architectural project proposal. The graphical results of this test were included in [4].

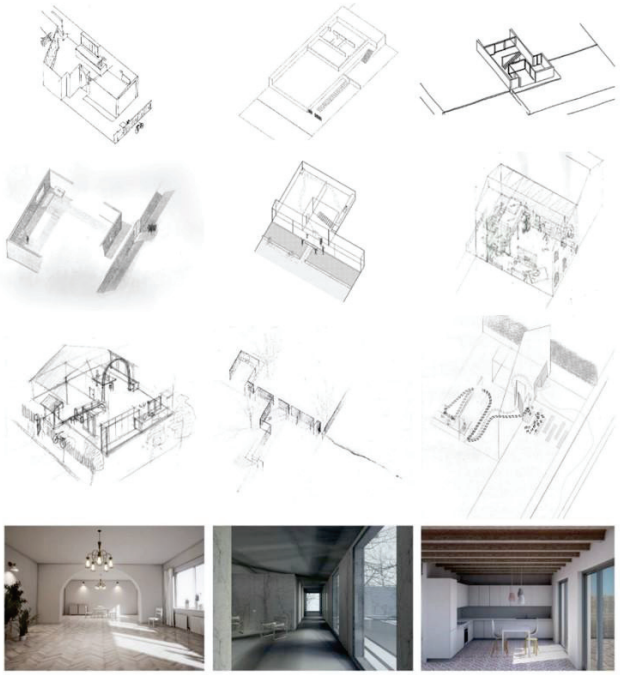

Image 3: A selection of 3D isometries and rendered images designed by ETSAB-UPC students in **test A**.

Test B was performed at the Faculty of Architecture from RWTH Aachen University. It included 34 normal hearing students, expert subjects, between the ages of 22 and 27. The experiment was set up the ITA hemi anechoic chamber, with individual headphone calibration, with 6 subjects being tested in parallel. The scene was auralized in RAVEN (ITA-RWRTH Aachen) using anechoic sounds. The results of these tests consisted of individual plan and section drawings made by hand, 3D isometry sketched by hand and questionnaire data. The acceptance of the pedagogical methodology used in the experience can be partially found at [1]. Additionally, trends in spatial perception can be detected by the statistical analysis of the questionnaires and the drawing dimensions, which is part of running studies.

Image 4: Some of the 3D isometries and rendered images designed by the FA-RWTH students in **test B**.

Other tests

In May 2017, a pedagogic test on architectural representation with architecture students in ETSAB was performed. This test aimed to evaluate the acceptancy of sound inclusion in architectural representation of urban spaces.

The 4th of December 2018, a mixing virtual and in-situ acoustics test was done in the Dominican Convent of Ausiàs March street in Barcelona. This test aimed to evaluate the realism of a synchronized audition of (1) the auralization of a trumpet playing in the church of the convent, and (2) the church's organ play.

Conclusions

The collection of tests performed shows that soundscape can be used as an engine for generation of architectural designs, in the instructive phases for new architects. In particular, soundscape is able to train the creative process demanded in the "insight" phase of the architectural design process: based on the same problem and programme presented in a sonic environment (the soundscape and the subjective perception of it), every student produce a different design proposals (the sketches). The subjective perception of the soundscape seems to be the key engine which generates the differences between architectural designs. Further study on subjective spatial arrangement, educational subject's background and acoustic perception trends will help to better understand this procedure.

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