Addressing sustainability in architectural education from urban to building scale: Reflections on the environmental design studio

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Abstract

Over the past decade, new approaches have emerged to renewable energy education to address the needs for sustainable energy supply systems. In addition, unlike conventional architectural education, which does not cover renewable energy issues in its curriculum, these days, renewable energy education has an identity of its own within the discipline of architecture. The fluid and multi-layered structure of the environment requires a broader perspective with a more expanded, cross-boundary knowledge and skills. In addition, a set of academic obstacles impeding the development of sustainable architectural education is explored such as ambiguous definitions and lack of experts in this field.

This paper mainly concentrates on the structure of architectural studies and the significance of environmental design. The study presents a descriptive reading through the experiences in the environmental design studio in the Architecture Department-Epoka University, and in this sense evaluates the outcomes within the educational process. The aim is to discuss the relationship between the interior/exterior or environment/building through the ideas created in the design studio. The key points are elucidated through examples of student work from architecture department. The reflections upon developing the knowledge of "environmental consciousness" and establishing the dialogue between different scales of environment on student work are examined and discussed in the scope of this paper

Key terms: architecture, education, environmental design, energy, performance

Introduction

Addressing sustainability in architecture is becoming a key issue. The incorporation of the architecture design within passive systems creates interesting, dynamic interiors supportive of human health and activities while reducing energy demand (Padovan and Del Col 2008). On the other side, done improperly, it impedes vision, causes discomfort,

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and demands excessive energy. Buildings were conjured throughout architectural history to use passive systems such as daylight, natural ventilation and traditional materials until electricity and technological developments such as air conditioning, fluorescent lighting, steel frames, and elevators enabled the economic construction of taller, deeper buildings (Notton et al. 2006).

Architectural education has the primary purposes of producing competent, creative, critically minded, and ethical professional designers/builders who contribute to the social, economic, and cultural development of society - both nationally and globally Architecture education is an interdisciplinary field that comprises humanities, social and physical sciences, technology, and the creative arts. The environmental control studio is a critical component of the architecture curriculum to develop capacity of building design in architecture education and to deliver energy efficient and sustainable buildings. The proposed format of the studio is a step in this direction to facilitate awareness on sustainability, building physics and energy simulation with the intent of sustaining the growth of these subjects within the architectural community.

The main objectives of the studio is to:

i. Develop capacity of students, studying built environment, in the fundamentals of building physics and energy simulation;
ii. To encourage and catalyze the incorporation of these subjects in the design studio;
iii. To facilitate a network of key architectural and engineering institutions allowing for future interactions and deliberations;
iv. To identify gaps and opportunities to enhance the architectural education to develop future professionals capable of delivering energy efficient and sustainable buildings; and;

The research method in this paper is based on the study in architectural education and the role of environmental control studio in the design process. The environmental control studio, as a methodology for supporting computationally all phases of an energy-conscious design and evaluation process, from urban to building scale is described. It combines procedural simulation and knowledge-based heuristic methods in one integrated system for the design and evaluation of environmentally friendly, solar and low-energy buildings.

Approach

The department of Architecture, Epoka University, has been offering to the second-year students a design studio entitled: Environmental Control Studio. The aim of the studio is to introduce students to environmental thinking through scientific approach. "Environmental thinking" is meant here in a wider sense, as both a technical and a poetical process. In the course of their studies, this is the first occasion for students to be confronted, technically, with environmental issues.

The studio course is divided into different phases. In the first phase students have to immerse themselves into the urban scale, the site, analyze the urban physics-technically-as well as their impression, perception, experience with various graphical means according to a series of themes in groups of 2 or 3. They included noting the natural materials on site, the natural and man-made elements or processes, the relationship between sky, land and water, acoustics, the topography, the climate, the uses, as well as the perception of scales and rhythms, banal and remarkable elements, fragile and permanent elements, and the wider planning context. Students are encouraged not to treat these themes as a research of facts, but as a way to concentrate their attention on some specific aspects of their perception of the site.

During the second phase (4 weeks), the students are focused on building scale. They are given scientific lecture on different topics; starting from daylight and artificial light, energy-related performance and diagnostics, acoustics, universal design, fire protection and HVAC systems. In addition to research papers, in groups of 2, they have to chose one environmental theme and develop a strategy for siting the buildings, which is a response to their previous experiential analysis and the environmental theme they chose.

At the same time, students had a final project. The aim of this study is twofold. On the one hand, it aims at making them feel the importance of architects' environmental and sustainability issues and its influence on the design process, by analyzing the architecture and urban design. On the other hand, it introduced them to a variety of environmental issues; in particular, describing their own approach to design.

Remarks on the project submission

Even though each team of students had different bias and insisted on different aspects of the design process in terms of environmental control and sustainability, research questions encountered by the students were somehow similar, and the final projects showed a homogeneously wide spectrum for each class. The different experiences the students had on the site and during the lecture, were the base of their arguments in the strategic development. However, they had difficulties in integrating the different spatial scales and topics into their final project.

The course forced students to become conscious of their own experience. The conscious process of putting it into words reinforced the unconscious learning process they went through. Indeed, the essays and the projects showed that students were well aware of the difficulties they had encountered, and that they were able to express it often very clearly. In the remaining part of the paper, we will summarize some of the issues touched upon.

Case study

Overview

As a result of urbanization phenomenon urban geometry of the city is transformed. Cities compared to suburban areas, have larger surfaces of non-impermeable materials and are lack of vegetation. Crucial inputs as surface materials, meteorological data and urban geometry are required to study indoor and outdoor thermal comfort.

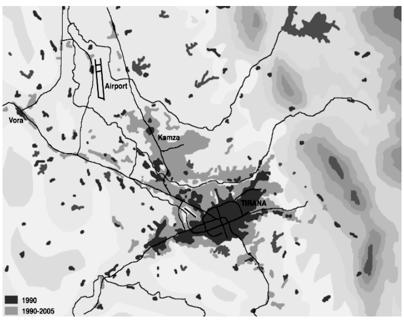


Figure 1 Urban expansion of Tirana from 1990-2005

Most of Urban Heat Islands impacts are spotlighted in hot humid climate, where its impacts are greater. Randomly there are carried out any studies on Mediterranean countries, with warm and humid climate. This study compares UHIs impacts on four different typologies of zones in Tirana:

i. Urbanized area (Tirana International Hotel, Center of Tirana)
ii. Semi-Urbanized area (Kindergarten)
iii. Closed typology of residential buildings (edifices enclosed in their perimeter)
iv. Non-Urbanized area (edifices surrounded by densely vegetation and soil environment)

Two main methods are applied to compute Urban Heat Islands intensity. The research performs a detailed site observation and surveys the inhabitants according to their indoor and outdoor thermal comfort. Furthermore, the study generates an evaluation between urban structure and meteorological conditions.

Study area and climate conditions

The city of Tirana is located 41° 19'48" N, 19° 49' 12". The city is 512 m above Adriatic Sea level. Tirana's average altitude is 110 m and its highest point is 1828 m. Hills on east side and a small valley on northwest surrounds the area. Throughout the city passes Lana River and are found four artificial lakes. Tirana is characterized by typical Mediterranean climate, with hot and dry summers, and cool and wet winters. Its average temperature is 15°C. The highest temperature of 42 °C is reached on July, while the lowest one of -10 °C is reached on January. The annual rainfall is 1265 mm. The lowest precipitations occur during August and September. The study area is spread in four different zones, based on different urban and climate conditions. Table 1 and figure 2 illustrates the description of the zone selection.

Table 1. Description of the zones characteristics

Zone 1	*Urban*	*Large surfaces of dark and impermeable materials, high density of building and heavy traffic.*	*High solar radiation and temperature, and low humidity especially during summer.*
Zone 2	*Semi-urban*	*Mostly occupied by residential buildings, few administrative buildings (hospitals, educational buildings, and municipal units) and plenty of uncultivated land.*	*Synoptic conditions are characterized by higher solar radiation and temperature than zone 3 and lower than zone 1. The presence of greenery is higher than zone 1 and lower than zone 4.*
Zone 3	*Closed typology of edifices*	*Surrounding pavement is of asphalt and bituminous materials.*	*The presence of solar radiation and wind is low.*
Zone 4	*Dense greenery and soil areas surround edifices*	*dense greenery and soil areas surround edifices. It represents a typical non-urbanized area, which has low density of buildings that do not exceed 2 floors story.*	*solar radiation is at the same levels as in zone 2 and 3. But it is characterized by a higher humidity and wind speed, compared to other selected zones.*

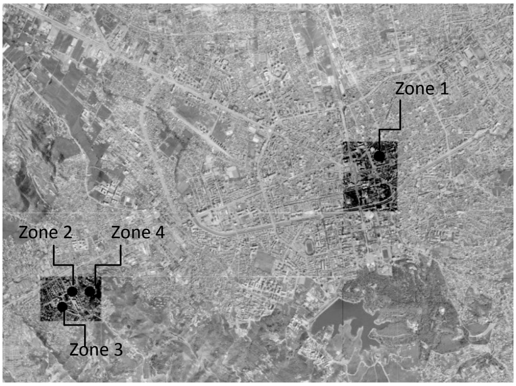


Figure 2 Location of selected zones

Methodology

Meteorological data

The measurements, performed during summer, from 1st June to 31st August 2012. Figure 3 illustrates the sample for June 2012. The measurements are taken each day at the same time in each zone 1 m over the ground level.

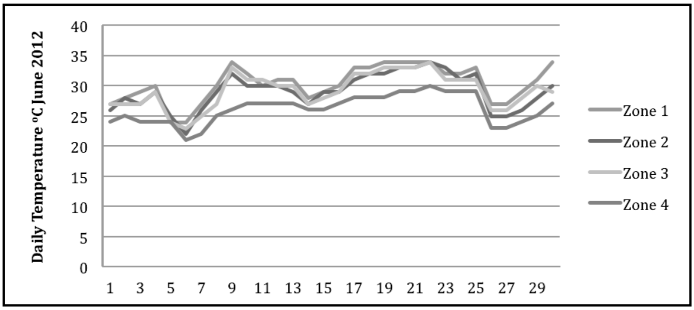


Figure 3 Daily air temperatures on June in selected zones

The data analysis aims to investigate UHI intensity and its impact on the outdoor comfort conditions. An initial elaboration is performed for the temperature measurements illustrated in figure 3. The highest temperature values among all zones are recorded in the zone 1 (city center) and the lowest is recorded in the zone 4, surrounded by densely vegetation and soil environment.

The temperature measurements indicate an increase of temperature in urbanized areas, compared to non-urbanized areas. Between zone 1 and 4 it is recorded a maximum difference of 9° C (Figure 4).

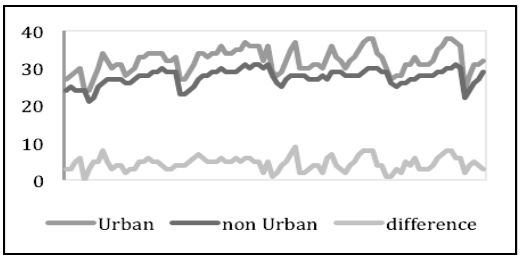


Figure 4 Temperature differences between zone 1 and 4

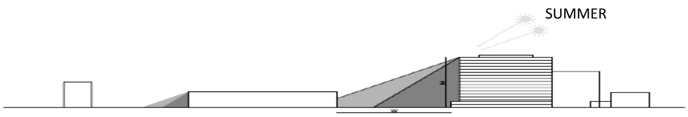
Microclimate and urban geometry

Urban canyons are strongly related with height-width ratio. The paper 'Effects of street design on outdoor thermal comfort' argues that H/W ratio affects the amount of energy transported into urban canopy, surface temperature, potential irradiation of canyon facets and potential of wind flow at street level (Toudert, Mayer 2006).

-Situation 1:

Within the zone, the selected building is the highest one and the ratio H/W is 1.15. The building of 46 m height lies on the extension of the boulevard of 40 m (figure 5). Due to location during peak hours of the day is totally in shade and protected from direct solar radiation. This ration is valid only in the western orientation while in south where the building faces the Skanderbeg Square the ratio H/W is lower and the area faces direct penetration of solar radiation. Consequently the surrounding environment gets overheated, due to paving materials (asphalt and bituminous products) and lack of being shaded.

Figure 5 H/W of the International Hotel, Zone 1



-Situation 2: Kindergarten and its surroundings

The width between the kindergarten and surrounding edifices as shown in figure 6 is wide, approximately 31 m, which does not allow the nearby buildings to shade south face of the kindergarten. H/W ratio is 0.25. Its location makes the kindergarten open to direct sun. The protection of indoor spaces from direct solar radiation is achieved by planting high trees with small canopies. The southern face is in shade.

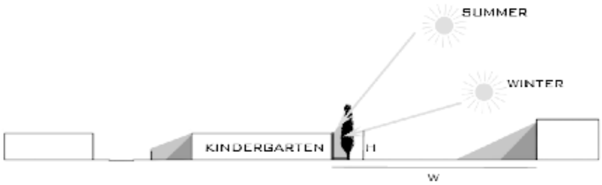


Figure 6 H/W ratio of kindergarten, Zone 2

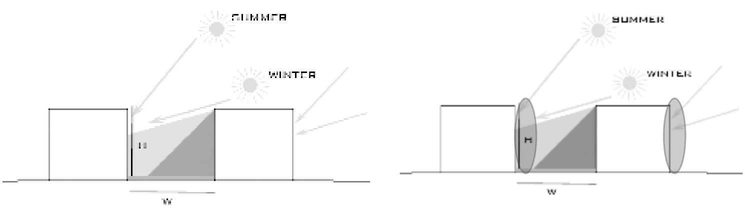


Figure 7 H/ W ratio in enclosed urban area

Figure 7 explains how UHI impacts are present in an enclosed urban area. One of the south faces is fully in shade in winter, meanwhile in summer it is completely unprotected. The small distance between the buildings decelerates wind speed, which increase heat storage in between edifices. In summer both faces are unprotected from direct solar radiation, which increases the potential for heat storage increase.

-Situation 4: Non-urbanized area

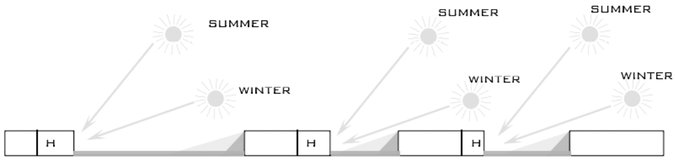


Figure 8 H/W ratio in non-urban area

Figure 8 shows the height-width ratio in semi-urban areas. This ratio varies approximately 0.16. The smaller is the ratio, the greater is the gap between edifices. Consequently southern faces are affected by direct solar penetration, as there is no permanent protection. The presences of greenery increase humidity and accelerate wind speed.

- Sky view factor
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Sky view factor is defined as viewing hemisphere occupied by the sky. In other words one part of the sky is visible in between the buildings, and another one is obstructed by them. Sky view factor is strongly related both with H/W ratio and surface materials. The greater the H/W ratio the greater is the SVF impacts. In this case having a narrow angle of SVF means that most of solar radiation is trapped between edifices area. Consequently the temperatures get higher. In absence of equipments sky view factor will be analyzed in analytically. Figures 9, 10 and 11 demonstrate SVF factor in all of three typologies of city geometry. In figures 9 and 10 , H/ W ratio vary from 0.2 to 0.56 while in figure 11 this ratio is 0.91. The first two cases represent two areas where SVF impacts are less evident instead of the third typology where solar heat is trapped between the buildings. Therefore the temperature tends to become higher in this zone.

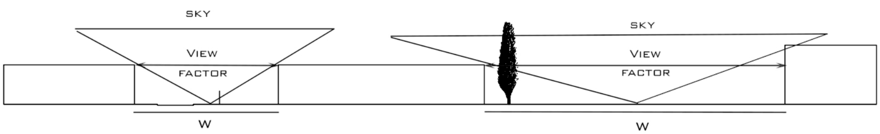

Figure 9 SVF at kindergarten area

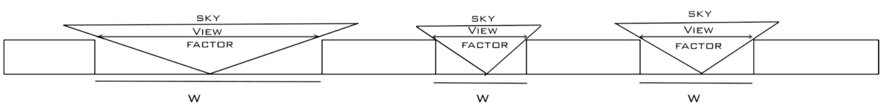

Figure 10 SVF at semi urban areas

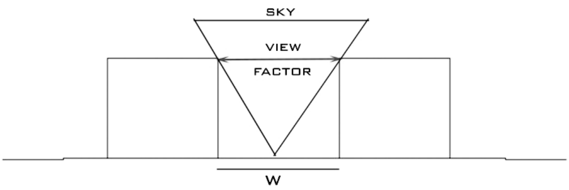

Figure 11 SVF at urban areas

Survey

The survey consists of an analysis of 75 habitants' behavior categorized into two groups: living in urban or non-urban environment. The average age of analyzed group is 31.6 where 62% are females and 38 % males. 64% of the interviewers are permanent habitants in the zones, while 36 % are pedestrians.

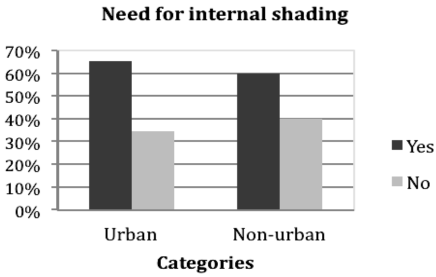

Figure 11 Need for internal shading of edifices

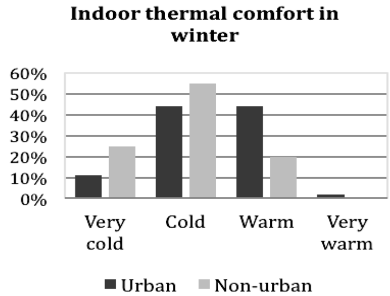

Figure 12 Indoor thermal comfort in winter

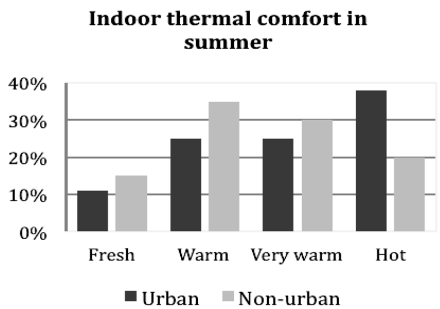

Figure 13 Need for internal shading of edifices

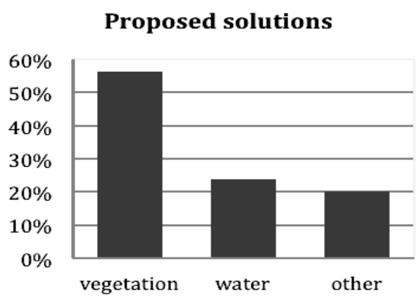

Figure 14 Proposed solutions

As illustrated in figure 13 in Zone 2; 52 % of the surrounding material is concrete, 25 % asphalt and just 23 % of the paving materials are greenery, including trees and grass.

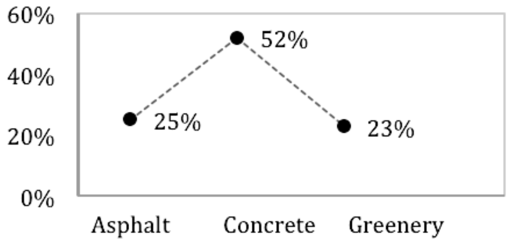

Figure 15 Material percentages in zone 2

The greenery in uncultivated lands (zone 4) is characterized by low vegetation, which usually does not exceed 1m. Meanwhile greenery spots in urbanized regions are denser and have big tree canopy.

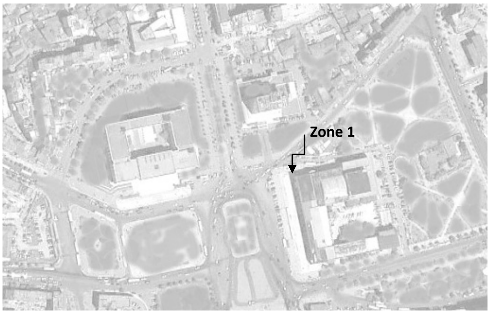

Figure 20 Greenery in Zone 1

Conclusion

The need for incorporation of sustainable energy supply systems into architectural education is becoming very important. Renewable energy education has an identity of its own within the discipline of architecture. The fluid and multi-layered structure of the environment requires a broader perspective with a more expanded, cross-boundary knowledge and skills. In addition, a set of academic obstacles impeding the development of sustainable architectural education is explored such as ambiguous definitions and lack of experts in this field.

This paper mainly focused on the structure of architectural studies and the significance of environmental design. It presented a reading through the experiences in the environmental design studio in the Architecture Department-Epoka University, and in this sense evaluates the outcomes within the educational process. The reflections upon developing the knowledge of "environmental consciousness" and establishing the dialogue between different scales of environment on student work are examined and discussed in the scope of this paper through a study of urban physics.

Urban Heat Island being the more documented phenomenon of climate change is usually expected to affect highly populated urban structures. The present study aimed to provide an additional quantitative analysis of the UHI in a Mediterranean City.

Analysis and experimental procedure taken in the four selected zones showed that UHI effects are seen more in the zones with a high urbanization, low vegetation, high percentage of concrete and asphalt material. The experiment was based also on an analysis of meteorological conditions of the city and temperature measurements on each zone at the same time for a period of three months during the summer. The results were clear that in the zones near the city center the temperatures were higher than in zones of periphery. Prospective works will profound the studies on these 4 zones, based on a more detailed observation of surroundings' structure with specified technical tools and simulation software program.

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