

# Teaching Climate Responsive Design to Beginning Architecture Students

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## Abstract

This paper describes some ideas and strategies implemented by the author in the teaching of ecological design to beginning architecture students at California State Polytechnic University, Pomona. All second year architecture students in our department are introduced to sustainable design in the spring of their second year. Lecture courses in various topics are integrated with the studio portion of the course, in which students design a sustainable building and evaluate its performance using different analog and digital tools.

*Keywords: Teaching Climate Responsive Design, Beginning Architecture Education, Sustainable Architecture, Carbon Neutral Design*

## 1 Introduction

There is no doubt now that humans are modifying climate IPCC [1] and that buildings are responsible for a major portion of green house gas emissions that cause climate change. Climate change is the single most important environmental threat affecting the earth and our existence as we know it depends on our ability to reduce the effect of buildings on climate change. For this reduction to occur, architecture schools must teach students how to design buildings with a reduced environmental impact. This is especially important in the United States, responsible for 350 GJ of energy and 15 tons of carbon per capita, and the largest single energy consumer and generator of carbon in the world. Educating architecture students is a process that occurs over several years, in which sustainability concepts have to be embedded in many courses. Introductory design courses in architecture provide the initial exposure of students to these concepts. In our initial lecture courses I provide an overview of

the issues and then focus on how to reduce carbon emissions by harnessing the sun and the wind.

Some of these general ideas have been introduced previously La Roche [2] and this paper introduces specific ideas and strategies implemented by the author in the teaching of ecological architecture in beginning design studios at Cal Poly Pomona University. Some of these have been adopted or adapted from discussions with fellow faculty or conference presentations, and have been organized by the author in an original way. Results have been very good, students have demonstrated that they can implement these concepts in their designs and have won several architecture competitions (<http://www.zerocarbon.design.org/>).

## **2 General Principle: Stewardship**

Architecture students should understand that they must become stewards of the environment, and for this to happen they must become ecologically literate. Ecological design in Orr's words is: "the careful meshing of human purposes with the larger patterns and flows of the natural world" Orr [3]. This principle is introduced in my first lecture as an expectation for the quarter. If students understand their role as stewards of the environment they will understand that everything that they are doing is framed by this principle.

## **3 Pedagogical Strategies**

### **3.1 Delve Deeper**

In order to have a more thorough understanding of sustainable design concepts, the student should go into more depth in their resolution. As Ralph Knowles suggests "It is time to re-evaluate the studio custom in most schools of architecture, starting with small and simple projects and advancing to ever larger and more complex ones. Usually, as students become more capable, the projects become proportionally more comprehensive and difficult. The result is that students often become progressively more skilful at making diagrams of shape and layout with increasing degrees of showiness, but not always with a deeper understanding of how the thing really works. What about delving progressively deeper instead of bigger, at least part of the time?" Knowles [4]. Second year is a perfect opportunity for this; a small project, or a portion of a larger project is developed to a greater level of detail. To do this appropriately the student must have a thorough understanding of sustainability concepts and the tools to test them. Magic arrows disappear to become real "tested" representations of air movement and radiation.

Emphasis is on development and evaluation of ideas, especially those connected with solar control and ventilation. Students evaluate the performance of their projects, or portions of their projects, in very rudimentary class built wind tunnels to test air flow, or with sun dials or digital modelling tools to test

shading and solar penetration or daylight levels inside the building. Simple energy modelling tools are used to determine energy consumption and CO2 emissions. Over the years, as students have become progressively more computer savvy, more digital tools have been introduced in this beginning design studio. Nevertheless, analog tools are always pertinent because of the stronger haptic connection established between the physical model and the student, which is difficult to achieve with digital tools.

### 3.2 Studio & Lecture Integration

There is general agreement that lecture courses and studios should integrate, but this is not always easy to do. Integration between studio and lecture courses, is key to the success of these courses in the quarter. Lecture courses are taught in sustainability, history of architecture, construction, and digital tools. Sustainability lectures focus on three major issues: comfort, climate and energy. Construction lectures emphasize building assemblies with typical construction materials such as wood and concrete. Digital lectures focus on 3d modeling. History lectures consist of an architecture survey that also includes readings and examples of contemporary sustainable design. Many of the lecture assignments are directly related with the studio projects and in fact deliverables are typically for two courses. Furthermore two of the design studio instructors usually teach the sustainability and construction lecture courses, allowing for a more seamless integration between studios and lectures.



Figure 1: Lecture & Studio Integration.

## 4. Environmental Principles

### 4.1 Understanding Energy and Natural Forces with Analog & Digital Tools

In the studio I emphasize understanding energy, the main “architectural factor” that affects climate change. In this introductory level this is in the form of solar radiation, daylight, indoor temperature and air movement. Students design buildings that use low energy materials and are able to operate with little energy. Beginning this year students also quantify the amount of CO2 emitted by their project compared with a typical building in the same climate zone, permitting

them to quantify their building's effect on climate change. Digital tools used in this studio can be of two types: modeling tools or analysis tools. Modeling tools are mostly used to develop the design and analyze shading, afterwards the digital model is used for thermal analysis. Analysis tools are usually *Very Simple Design Tools* or VSD Tools La Roche & Liggett [5] that are fast, easy to use and provide sufficient precision for what is required in the initial phases. Some of these digital tools are Climate Consultant and HEED developed at UCLA (<http://www2.aud.ucla.edu/energy-design-tools/>) Milne, Liggett, Alshaali [6] and the Weather Tool and the Solar Tool developed by Square One (<http://www.squ1.com/>). Some of the students also determine daylight factor with illuminance meters and physical models, or with digital models and Ecotect.

#### **4.2. Passive Solar**

Low energy buildings should result from appropriate design of the envelope and its architectural components instead of the implementation of complicated HVAC systems and controls. Passive Solar Architecture is the most effective way to reduce CO<sub>2</sub> emissions and the importance of regulating the forces of nature through building design is emphasized in the studio. Because of limited lecture time emphasis is on a few passive heating and cooling techniques that are appropriate to the site's climate. This has usually included passive cooling strategies such as nocturnal ventilative cooling and evaporative cooling, and heating strategies such as direct gain systems or Trombe walls.

#### **References**

- [1] Climate Change 2007: Synthesis Report, An Assessment of the Intergovernmental Panel on Climate Change, Valencia, Spain, 12-17 November 2007, Working Group contributions to the IV Assessment Report.
- [2] La Roche, P., Teaching Architecture in a Changing Climate, TIA Conference, Krems, Austria, 2007.
- [3] Orr, D., "Environmental Literacy: Education as if the Earth Mattered." E. F. Schumacher Lectures, 1992.
- [4] Knowles, R., *Proposal for conference on Sustainability in Architecture and Higher Education*, February 26-27, 2007.
- [5] La Roche, P., Liggett, R., "Very Simple Design Tools: A Web Based Assistant for the Design of Climate Responsive Buildings", *Architectural Science Review*, vol. 44, pp. 437-448, 2001.
- [6] Milne M., Liggett R., Alshaali R., Climate Consultant 3.0: A Tool for Visualizing Building Energy Implications of Climates, Annual Conference of the American Solar Energy Society, Cleveland Ohio, 2007.

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