UNIVERSITY of NOTRE DAME
School of Architecture

DESIGN VI/ ARCH 41121 (& AME 47431)

BUCCELLATO STUDIO SPRING 2016
Environmental Stewardship through Interdisciplinary Research and Design

PROJECT 2:
CRITICAL CIRCUMSTANCES

ISSUED: JANUARY 22, 2016

Introduction:
In 2000, at the *World Education Forum* held in Dakar, Senegal, 164 governments launched an ambitious global agenda, the *Dakar Framework for Action, Education for All (EFA): Meeting Our Collective Commitments*, aimed at achieving six principal education goals by 2015[i]. Though progress towards these goals has been made over the last fifteen years, according to the 2015 EFA Global Monitoring Report, 58 million children across the globe still remain out-of-school and 100 million children are not expected to finish their primary education[ii] (US grades K-6). A recent paper released jointly by the UNESCO Institute of Statistics and the United Nations Children's Fund (UNICEF) reveals that the number of out-of-school children and adolescents is actually on the rise[iii]. To reverse this trend and achieve their previously stated goals – universal primary and secondary education for all children – the Out-of-School Initiative (OOSCI) joint report calls on the international community to dramatically increase aid for education, with particular focus on distribution to those countries that are currently furthest away from achieving these goals.

While lack of funding is a principle barrier to access to primary education, lack of infrastructure, teachers, and classroom space are also significant contributing factors. Importantly, studies related to the OOSCI report have shown that the "build it and they will come" approach has not necessarily produced lasting change in the most vulnerable populations. Therefore, calls for increasing aid and new distribution models must also be met with increasing discernment about *how* the aid is utilized, relative to potential for greatest impact, and specifically in the design and construction of new schools to support EFA goals.

Project Description:
Building on your recent study of the influences of climate, site, local materials, technologies, and culture on architecture and form-making, this exercise is designed to expand your growing knowledge of site responsive architecture and methods for achieving it in the design of a sustainable primary school. With funding from the prominent Foundation for Education and the Environment[iv], each design team (4 students: 2 ARCH, 2 ENG) has been asked to design a model school in a rural developing context that responds to two pressing global challenges: education inequity and climate change.

Site Selection:
To meet the Foundation's funding criteria, each team is responsible for site selection for their school based upon a combination of factors:

1. **Vulnerability** (high, of the site/region) to the effects of climate change *and* access to primary education
2. Ability to **adapt** (low, of the site/ region) relative to infrastructure and resources to climate change and EFA goals to address universal educational opportunities (including things like computers and access to the internet)
3. **Viability** of renewable energy sources in the selected context

To determine the *specific* site for your school, each team will refer to the following resources:

1. The ND Global Adaptation Index (ND-GAIN) usefully illustrates regions and specific countries that are currently most vulnerable to the consequences of climate change and those that are similarly least able to cope with change. http://index.gain.org

2. The WIDE Index, a database developed by the Education for All Global Monitoring Report that describes worldwide inequality in education according to factors such as location, ethnicity, gender, and wealth.

Using these indices, each design team will evaluate potential sites based upon their viability to support all school and school-related community activities using one of four renewable energy sources: solar, wind, hydro, geothermal. Additionally, each team will be assigned to design their school in one of the four climate zones (hot, mild-temperate, humid, or cold).

Building Program[v]:
Once a site has been selected, the *base* building program for the primary school is as follows:

Classrooms (6); one for each grade, 1-6 (each classroom to hold between 20-40 students)
Faculty Offices:
- Teacher Offices (single office or series of offices)
- Headmaster's Office

Bathrooms:
- Separate male and female facilities
- Separate bathroom for teachers

School/ Community Gathering Space (can be as informal as a courtyard)

Additional programmatic considerations:
- Library/ Computer Room
- Water Collection System
- Teacher/ Student Gardens (can be used as an educational tool and a resource for school lunches)
- Cooking Facility (depending on site, can be informal and outside)

Basis of Design/ Fundamental Considerations:
Model schools, such as those developed by non-governmental Organizations that have been deemed both successful and sustainable are typically community/ site built, using local materials and methods of construction, employing a predominantly local (or community-based) construction force. The most successful structures are contextually relevant (appropriate in place and function) and anticipate future development. Many of these schools utilize design-integrated useful technologies and methods to make the schools self-sufficient (renewable energy sources, rain water collection devices, school gardens) and meanwhile promote high attendance and increased student performance.

The long-term sustainability of these schools depends on community involvement over the life of the school. Instilling a sense of community ownership can be achieved by involving members of the community in the physical construction of the school so that they can learn useful construction techniques and by encouraging communal activities in the school (performances, skills training, sports events, etc.) by providing meeting space. Therefore, your building design (and operating) strategy should anticipate shared use by the community of the Gathering Space and Classrooms for Parent-Teacher Association (PTA) meetings, community meetings, evening tutoring sessions, or similar after school events.

Building Performance Energy Analysis & Renewable Energy Strategy
In order to obtain a realistic understanding of your school's energy needs – i.e., in terms of envelope design to achieve and maintain baseline thermal comfort for all occupants as well as system(s) capability to

support primary activities throughout the year and including anticipated primary plug loads – energy analyses will need to be conducted.

Energy analyses that are useful in a design process include considering building massing, orientation, external shading, and envelope materiality. For this exercise, you should assume ***the absence of an active/mechanical thermal management system*** (forced heating or air conditioning). That is, the building should be able to provide suitable thermal comfort without any mechanical systems. To achieve a structure that can achieve these baseline performance goals, the ARCHs and the ENGs from each team must work closely together to rapidly iterate and analyze their developing designs to arrive at a structure that can support all programmatic requirements and be self-sustaining. Energy analyses will be conducted using Sefaira as a plug in to either SketchUp or Revit. More information on how to utilize Sefaira and SketchUp/Revit for this exercise is included in the accompanying Energy Analysis Tips document.

Additionally, as presumably these students will need access to electricity, you need to assess the viability of using a renewable energy resource on site at your school to support its electrical demands. This will include determining the viability of solar, wind, hydro, or geothermal technologies for the location of interest, and a preliminary estimate of the power that can be produced at the site and the capital cost of such a system. A number of organizations have conducted and compiled such analyses (World Energy Council, International Renewable Energy Agency, Center for Climate and Energy Solutions), and each design team is encouraged to consult these resources. Additional suggestions for approaching this aspect of the project are included in the accompanying Energy Analysis Tips document.

<u>Broader Project Objectives:</u>

1) **Develop an appreciation** for the unique challenges of development projects that aim to address an acute problem in typically unfamiliar locations (and using potentially unfamiliar architectural languages, materials) and always with limited resources. Such projects may necessarily change – or at least challenge – a "normative" process of design, with any resulting innovation, whether in process or product, being ultimately human-focused and necessarily both environmentally and culturally sustainable and sensible.
2) **Gain experience** participating in a tightly-coordinated, collaborative design process in a project that requires rapid, iterative interaction between ARCHs and ENGs to achieve fundamental project goals.
3) **Expanded understanding** of "high performance" building design and specific methods for achieving a design solution that optimally negotiates cultural and physical performance goals, functional priorities, and myriad critical circumstances.

<u>Project Deliverables:</u>

The primary focus of this project is to present a concise and methodical <u>graphic description</u> of the iterative collaborative design process (i.e., <u>*not*</u> traditional final design presentation drawings).

Your <u>*successful*</u> completion and presentation of Project 2 requires the following (at minimum):

- The sequential organization of *diagrams* that <u>document the design and optimization *PROCESS*</u>, from beginning to end, including each stage of design, analysis, modification, and performance feedback, leading up to the final design (optimal configuration) of the school.

- Diagrams must clearly, consistently, and legibly describe *in graphic form* your *DESIGN PROCESS,* such that a "flip-book-like" series of concise building massing (or envelope) diagrams can be assembled to describe – or better yet, animate – your iterative design process and to illustrate the specific climate/ context (etc.) forces on building form, including responses to thermal analyses, predicted thermal comfort, and energy use

- Bibliography
- Technical Memo (ENG's; five page maximum, follow required format): Detailed description of thermal analysis approach, assumptions, results, and discussion.

You are strongly encouraged to determine your presentation format for the "flip book" from the outset of the design process, so that your means for capturing and documenting your process works in support of (or is carried out in) the final presentation medium. Consider how you will incorporate fundamental technical information (materiality, strategies for ventilation, lighting/ daylighting, etc.) in your process drawings and how you will achieve a highly streamlined, concise, and sharp presentation.

Additional Project Resources:

World inequality database on education (WIDE): **http://www.education-inequalities.org/**

UNESCO Global Education Monitoring Report:
http://en.unesco.org/gem-report/sites/gem-report/files/2015_report_dataviz/index.html

EFA Global Monitoring Report 2015

World Energy Council: https://www.worldenergy.org/

International Renewable Energy Agency:
http://www.irena.org/ (http://www.irena.org/potential_studies/)

International Energy Agency: http://www.iea.org/

Center for Climate and Energy Solutions: http://www.c2es.org/energy/source/renewables

DEADLINE FOR PROJECT 2: Friday, February 5 @ 1:30 pm

PROJECT 2 REVIEW: Friday, February 5 @ 1:30 pm

DEADLINE FOR PROJECT 2 TECHNICAL MEMO: Monday, February 8 at 1:30 pm

---

[i] World Education Inequalities Index: http://www.education-inequalities.org/
[ii] 2015 EFA Global Monitoring Report. (2015) UNESCO. Second edition. United Nations Educational, Scientific and Cultural Organization.
[iii] Fixing the Broken Promise of Education for All; Findings from the Global Initiative on Out-of-School Children: http://www.uis.unesco.org/Education/Documents/oosci-global-report-en.pdf (accessed 12/15)
[iv] An entity imagined
[v] Portions of the base building program have been adapted from the building program developed by Building Tomorrow, a non-governmental organization that builds schools in rural Uganda.

PROJECT 2:
CRITICAL CIRCUMSTANCES

ENERGY ANALYSIS USING SEFAIRA

Sefaira Architecture is an energy analysis program that takes structures generated in SketchUp or Revit and performs energy load analysis. That is, it assesses the energy load (heating or cooling) to offset the multiple energy fluxes into and out of a building in order to maintain a pre-specified temperature. This type of analysis is good at the planning stages of building design because it can rapidly be used to assess basic design decisions (location, size, orientation, etc.) on the energy performance of a building. Typically this energy performance is measured in EUI or Energy Use Intensity – the total energy consumed by the building per unit area (http://www.archtoolbox.com/sustainability/energy-use-intensity.html). A great article on this metric and zero net energy buildings can be found here:
http://www.nrel.gov/sustainable_nrel/pdfs/49103.pdf

For this project, however, we want to analyze what the temperature would be *if there was no active heating or cooling*. This is called thermal comfort analysis and in essence consists of conducting an energy balance on the building without any heat sources or sinks – much like you did in Project 1. Sefaira has this capability, but one drawback is that it only determines the number of hours spent *outside* a thermal comfort range of 64.4°F to 82.4°F. For more information on this capability:
https://sefaira.zendesk.com/hc/en-us/articles/202286329-Thermal-Comfort-FAQ
https://sefaira.zendesk.com/hc/en-us/articles/202286959-Video-Using-Thermal-Comfort-Analysis-to-Investigate-Overheated-Underheated-Hours

ASSESSING RENEWABLE ENERGY VIABILITY

In order to assess the viability of a renewable energy technology, it is necessary to determine (a) the energy need of your building, including energy types (in this case, electricity), (b) the availability of a specific energy source (solar, wind, geothermal, hydro), and (c) the capital costs. For this exercise, we will focus on the first two aspects of this exercise.

(a) In assessing the electricity need of your building, one of the first steps is to determine the *plug loads*, which is essentially the energy used by products that are powered by means of an ordinary AC plug. The simplest way to do this is a *virtual walkthrough*, where you consider the electrical equipment required in your building (computers, refrigerators, lights, etc.) and assign energy consumption based on energy use (type of instrument, number of hours in operation, etc.). There are a number of tools online that can potentially help in this estimate such as the following:

- http://www.wattstopper.com/design-tools/energy-calculators.aspx#.VpVrdMArJkg
- http://www.energystar.gov/sites/default/files/asset/document/Office%20Equipment%20Calculator.xlsx

More information on this process and additional tools are available through the Better Buildings Alliance of the U.S. Department of Energy.

- https://www4.eere.energy.gov/alliance/activities/technology-solutions-teams/plug-process-loads

Note, however, that all these tools and information focus on office buildings and other large buildings. You will potentially have other considerations for the school you are designing.

(b) In assessing the specific renewable technologies, it is typically useful to use resource maps that identify if your location is particularly suited for a specific renewable energy source. For example, you can certainly determine by intuition that South Bend, IN does not have nearly as much available sunlight for solar power as say, Phoenix, AZ. Again, there are a number of resources online that help walk you through this process, with the most succinct being from the U.S. Department of Energy Office of Eenrgy Efficiency and Renewable Energy (focus on the preliminary and screening components of this guide).

- http://energy.gov/eere/femp/assessing-renewable-energy-options

Again, this resource is directed at renewable energy options in the United States. However, there are a number of resources available through a number of other organizations as listed below.

- World Energy Council: https://www.worldenergy.org/
- International Renewable Energy Agency: http://www.irena.org/ International Energy Agency: http://www.iea.org/
- Center for Climate and Energy Solutions: http://www.c2es.org/energy/source/renewables

Many of the documents on these websites are provided through Box for your convenience. The International Renewable Energy Agency, in particular, has collected a number of studies on the potential of renewable energy for countries across the globe (http://www.irena.org/potential_studies/). Many of these studies may in fact already have the answers you are seeking for your particular region.

In addition to looking at resource maps, other tools and online calculators are available through the U.S. Department of Energy, National Renewal Energy Laboratory, and similar entities in other countries. Some of these tools are listed here:

- http://energy.gov/eere/femp/renewable-energy-maps-and-tools
- http://www.nrel.gov/analysis/models_tools.html
    - PVWatts: http://pvwatts.nrel.gov/
- http://www.retscreen.net/