California Polytechnic State University, San Luis Obispo

From the Selected Works of Thomas Fowler IV, DPACSA, FAIA

Summer July, 2016

Crossing Boundaries: Blurring the Lines Between Engineers and Architects

Thomas Fowler, IV
Kevin Dong

Available at: https://works.bepress.com/tfowler/15/
ABSTRACT: For the past three years an interdisciplinary studio has teamed students, academics, and practitioners to develop a master plan, college buildings and housing designs for a Polytechnic College in Tanzania, Africa. Since 2012, groups of architectural majors and architectural engineering majors developed a master plan for the college and most recently developed plans for housing and classroom facilities. The project requires students to think differently – recognizing and developing building solutions which account for cultural differences, material differences, technology differences, and resource differences; when compared to those typically designed for in westernized areas. The driving objective was to design using indigenous materials in innovative ways which minimize maintenance, address longevity issues, and implement energy and water conservation and collection. The paper will highlight lessons learned, class activities, and exercises which aided student mastery of materials, space, structures, and sustainability issues.
It is the intersections between architecture and engineering that form the basis for collaborative design laboratories or the “Collaboratory” at Cal Poly in San Luis Obispo. In the Collaboratory students hone their structural and architectural skills, but also learn how their disciplines are intertwined with the allied specialties.

In his Key Speech\textsuperscript{1}, Ove Arup describes the melding of disciplines to create a holistic design. To achieve this, professionals from all disciplines work together as a team. The team develops the design parameters, but also engages in discussions about construct-ability and material alternatives. At all stages of design, engineering decisions are evaluated from different perspectives to arrive at comprehensive, inclusive, and seamless designs. The idea being the design of one element influences another and designers need to understand the impact of their decisions on allied disciplines. As an example, the building designs for the Same Polytechnic rely on readily accessible and cost effective materials, natural ventilation and daylighting to minimize energy consumption and maximize thermal comfort. These are not typical issues that influence structural design, but for the Same Polytechnic, these considerations impact the design of approach for the structural system.

2 GETTING STARTED

2.1 Starting from scratch

The studio attracts both undergraduate and graduate students, continuing and exchange students, and students from within the college and outside the college. As such, students enter the course with varying design experience and skills, as well as, from different majors within the built environment. The Same Polytechnic project neutralizes student advantages or disadvantages, relative to each other, because the project requires students to think differently. They must consider a culture unlike their own, an environment unlike their own, similar materials, but designed and constructed in ways different than what they know. This means all of the students are starting anew and are on equal footing; relying on design theory and basic engineering principals to develop strategies for structural systems and architectural vocabularies. Since the students are starting from “scratch” the instructors have developed a series of exercises that help groups develop team work strategies, understand lines of communication, and gain new perspectives on building with unitized systems.

2.2 What is Collaborative Design: How do we blur the lines?

The core fundamentals of design and engineering become necessary tools for proposing new methodologies and alternative building techniques when using familiar construction materials. That frames the technical component necessary for success, but architectural and engineering design requires a fluidity and creativity to create solutions that are efficient, aesthetic, and economical.

Figure 1: First Activity – Deconstructing and Reconstructing Modules
The first activity, as shown in Figure 1, requires students to use a simple object, deconstruct it, then create a module with the deconstructed object, then assemble the module to form a structure. During this exercise the students have used forks, spoons, and most recently, cups. The problem requires student teams to use small paper cups, dixie cups, to create a small structure which can span two steps and can support a small uniform load. The last criteria is to minimize waste. As seen in the images below, the cups are cut, re-shaped, and connected to form building modules and systems. All of the student teams describe their process, which allows the faculty to assess team dynamics and workflow patterns, and describe their iterations in design to assess if the group why some ideas worked and others did not. The “exhibition” of the simple models allow the instructors to highlight connections, building patterning, and construct-ability issues related to building design, but also call attention to the importance of solving aesthetic issues simultaneously with stability issues.

2.3 What we didn’t tell you...

Communication is important, and the ability to communicate both verbally and graphically are requisite skills in design and allow one to overcome language barriers - both technical and cultural. Students are required to read and discuss excerpts that graphically show and technically discuss design process, such as Fractile and Bordeaux Villa, from an engineer’s perspective. Then the teams research the same buildings to gain the architect’s perspective. The goal is to instill a method in which ideas can evolve, how ideas are promoted, and how engineers and architects interact and communicate with each other.

One student commented that, “after midway through the quarter, I realized it was quicker and clearer to explain my thoughts and design concerns using quick sketches. It not only helped get my thoughts across, but also made it understandable to my partner”.

2.4 What is work flow?

During the first week, the groups participate in a Collaborative Design workshop. The workshop is conducted by alumni and friends of the program that work in either multi-disciplinary engineering firms, or work on projects that use delivery models that require collaboration from the inception of the project. The idea is to provide a model for work flow and to understand how their team operates. The two day workshop starts with icebreaker activities, but the workshop revolves around a small design project, such as a student club space on campus. The groups are reviewed via desk crits, but the reviews consist of some design strategies and what design issues are important. It also serves as a means to show that the design process is not linear, that the design concept does not start with the architect, then get handed off to the engineer, then after coordination get handed off to a builder.

Figure 2: Collaborative Design Workshop
3 THE PROGRAM

3.1 The introduction:

Students are introduced to the project through a series of short research assignments, guest speakers, and the travel experiences of the instructors. Students research the Tanzanian culture, weather patterns, rainfall amounts, available building materials, structural building systems, and the education system. The students discover the major differences between designing in the western hemisphere and in Tanzania are the following:

- The people of Tanzania are social, it is common for individuals to greet each other and engage in meaningful conversation when their paths cross. Therefore, the campus layout should provide social nodes based on pedestrian traffic patterns.
- Most Tanzanians stop their schooling at the middle school range. Tanzania has one of the highest rates of poverty and lowest levels of education per capita. Higher education is needed to help end poverty and to provide an educated workforce for the future growth of the country.
- There is no word for “maintenance” in Swahili, thus up keep and annual servicing is a cultural shift. Typically, equipment is fixed when broken versus providing regular maintenance to prevent something getting broken.
- Adobe and confined masonry are the materials of choice. Wood has a short term design life due to the extreme solar conditions. Steel and concrete may be used as building materials but there is a cost premium for these materials and size availability is limited. For instance, small tube sizes (up to 2 inches square) and reinforcement smaller than a #5 are readily available. Larger sizes may be purchased at a premium and will need to be ordered or imported.
- Labor is inexpensive, so economical designs should incorporate simple, repeatable cuts which can be completed with hand tools. Also, quality construction can be achieved and repeated when designs address sequencing, constructability, and the skills of the work force.
- The weather in Same is temperate, but very humid. Although the temperature average is approximately 80°F, the humidity level is higher than that in California. Therefore, air movement is a critical design parameter when considering thermal comfort.
- The site is located slightly south of the equator. This means the solar angles and solar protection strategies are different. The north and south building faces behave similarly and the east-west faces behave similarly. In the western United States, the north and east facing surfaces require the least amount of solar protection.

The comparisons of designing in their home state versus designing in Tanzania, reinforces the differences that should be addressed to create successful design proposals.

3.2 Rules of Thumb and Guiding Principles

The engineering students provided the architects with rules of thumb to help proportion the building massing and wall fenestrations. The rules of thumb are driven by material strength, optimization of natural ventilation, or minimization of direct solar gain. Additionally, the student groups develop fundamental principles which guide students when offering alternative solutions. The group evaluates structural and architectural solutions not only for technical merit, but also for adhering to the design philosophies implemented in the project.
3.3 Interim workshops and mentoring

Midway through the term, a team of engineers and architects visit campus to conduct a two day charrette. The visiting team typically consists of structural, mechanical, electrical, and civil engineers, plus architects. During that time, students present their work to the group followed by a short question and answer period – similar to traditional critique sessions. The following day, the guest reviewers divide into smaller interdisciplinary review panels and rotate amongst the student groups to provide specific comments and suggestions for consideration. The guest reviewers rotate through all of the groups so that each receives input for each discipline. At the end of the session, the student groups compile the comments and present their proposals for design modifications and how the new proposals address the concerns identified by the guest reviewers.

This part of the class has been identified as one of the strengths of the class. The interim feedback from practitioners in a one on one environment allows students to work in situations similar to practice. One where questions are posed, solutions are offered, and the results are debated.

![Interim Workshop with practitioners](image_url)

3.4 Final Reviews

The final reviews are conducted off campus. Reviews are typically held at a multi-disciplinary engineering firm where design professionals from structures, mechanical, civil, sustainability, acoustics, and architecture participate. It is common to have 12 to 16 reviewers for a given presentation. At this stage of the project, students receive constructive criticism about overall systems, element design, and construct-ability. As an example, it is common for professional structural engineers to comment holistically, such as;

- how a confined masonry building will behave in a seismic event
- whether or not a connection detail provides a realistic means for load transfer
- if the proposed detail is “constructable” and suggestions for simpler methods of construction.

The review panel is large, but this allows feedback from a variety of perspectives and ultimately allows for a stronger project. After the reviews, the student teams are given one week to incorporate the comments into their designs and describe how the changes address the comments received during the final review. This is a crucial step in the process, since the goal is to build the project and it is imperative that all comments be addressed, but not necessarily incorporated.

4 CONCLUSIONS AND REFLECTIONS

The Same Polytechnic studio is the outgrowth of a decade of learning, by students and faculty alike. The college has offered an interdisciplinary studio with architects and engineering students since 2005. During this time, this studio genre has developed from a course that intro-
duced students to collaborative and integrated design to a studio in which students learn how to develop engineering and architectural systems which address structure and form, orientation for natural daylighting and ventilation, material selection for strength and durability, and systems integration for constructability and cost.

The students appreciate the exposure to multiple disciplines and often comment that it reflects real world situations and helped them prepare design proposals which better addressed the building issues. Student comments:

*I find that working with people from different disciplines is advantageous because it provides a variety of perspectives and ideas on how to accomplish the task at hand. It helps develop a holistic outcome as more paths to success are considered. Collaborative experiences simulate an environment that is representative of life after college.*

*Working with Brandon and Zack was very informative in many ways. I began to notice how each of our disciplines affected our resolutions to problems or what we thought to be vital to the overall design. While Tyler and I were concerned with the structure’s overall performance, Brandon explored ways to implement landscaping as Zack investigated spatial relations and comfort aspects. I began to think differently about our project as I became aware that the balance of these elements would lead to a successive, holistic design.*

*Bringing a variety of expertise to the table at the beginning of design results in a stronger and more cohesive design. Learned through field trip to ARUP, hearing the different professionals’ opinions on our project.*

5 ACKNOWLEDGEMENTS

The benefits of an interdisciplinary experience for students at Cal Poly have grown exponentially during the decade of teaching. This would not be possible without the initial collaboration in 2005 when Professor Thomas Leslie at the University of Iowa combined his architectural design studio with the author who taught a structures based engineering studio to design a hypothetical glider port in San Francisco, California.

The authors also thank Professor Jim Doerfler at Philadelphia University. Jim was a collaborator and co-instructor while at Cal Poly and remains a valuable colleague. He was instrumental in developing the collaborative studios and initiating ties with industry partners.

6 REFERENCES


Balmond, C., informal, Munich, Germany, Prestel, 2010, 5th Edition
