AC 2008-1512: CONNECTING ARCHITECTURE WITH STRUCTURES

Kevin Dong, California Polytechnic State University

Kevin Dong, S.E. is an Associate Professor of Architectural Engineering (ARCE) at Cal Poly – San Luis Obispo. For the past six years he has been teaching classes that emphasize structural systems and structural design to various majors (Architecture, Architectural Engineering, and Construction Management) within the College of Environmental Design and Architecture. His class work utilizes his 13 years of experience with Ove Arup & Partners (ARUP), where he worked in both the San Francisco and London offices. A trademark of all the projects was the concept of integrated design where the building solution incorporates the design efficiencies and aesthetics from each building discipline. This approach to design is stressed in all of his courses for engineers, architects, and construction managers alike.

Connecting Architecture and Structures

Introduction

Five years ago two instructors were working professionals. One was a design architect for Norman Foster & Partners and the other a building engineer for Ove Arup and Partners. Today, both are instructors, but they teach at institutions separated by two time zones. One teaches architecture, the other teaches structures. As educators, the primary goal is to prepare students for life after college. To that end, a class was developed to emulate real world practice, where students are exposed to the trials and tribulations of communication, negotiation, and the total design process. By exposing students to a class that emulates practice and to issues which design professionals face on a daily basis will better prepare them for practice and life after college. This "experimental" course has been offered thrice and student feedback indicates exposures to the first two soft skills were the most demanding – just like practice.[1]

Overview

As noted previously, a primary goal for college professors is to prepare students for the future. We do this by,

- Teaching critical thinking skills to develop problem solvers for the future
- Creating speaking and writing opportunities to enhance communication skills
- Developing group projects so individuals learn about group dynamics and the nuances of negotiation
- Prepare situations that require scheduling, coordination amongst multiple parties, and defining a scope of work to develop project management skills
- Exposing students to problems that reflect real life situations so students can apply previous coursework to "real" problems

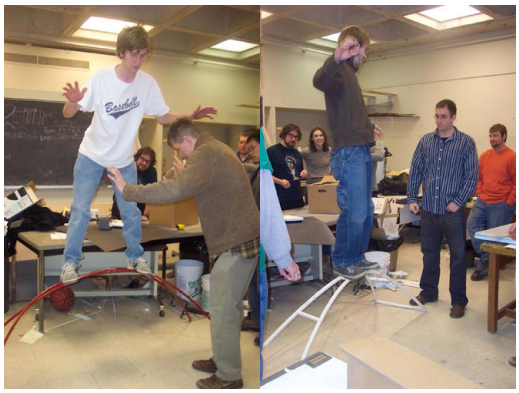
Last year the two instructors developed a collaborative design studio that incorporated a steel design competition sponsored by a professional organization. The design process was complicated by the fact that the two design teams, architecture and structures, were not located at the same location – just like practice. A steel competition was selected because it presented a building with a modest but well defined program, an opportunity for creative architectural and structural design, and presented a building type that all the students could relate to. The course required design meetings at each college campus, project documentation of all design team correspondence, project calculations and drawings, and project reviews by practicing engineers and architects.

The course was completed over a six month period and the schedule was developed using the instructor's years of experience in practice. One of the keys to success in practice is the formation of partnerships.[2] To that end, two design team meetings were scheduled, one at each campus. These multiple day gatherings allowed the students to discuss design issues face to face, as well as providing a vehicle for the students to form friendships outside of class. At both meetings, the host school provided transportation to and from lodging and tours which showcased points of interest after "office hours". These meetings were instrumental in stressing

the importance of face to face communications and helped open the lines of communication when the design teams were at their respective institutions.

Connecting

To initiate team communication and lay the ground work for future collaboration an "icebreaker" activity was assigned at the school of architecture. (Based on the previous year, we wanted to start the concept of collaboration as early as possible.) The program was short and required correspondence between architectural and structural teams even though they did not know each other at that time. The emphasis was on correspondence and coordination. The week long task was to create a structure that could span over a basketball and support 200 pounds while adhering to a ten dollar budget. Even at this scale, students were exposed to the differences in "design" priorities and the differences in the language used by architects and engineers. But to reiterate, the goal of this exercise was to get the two parties communicating.



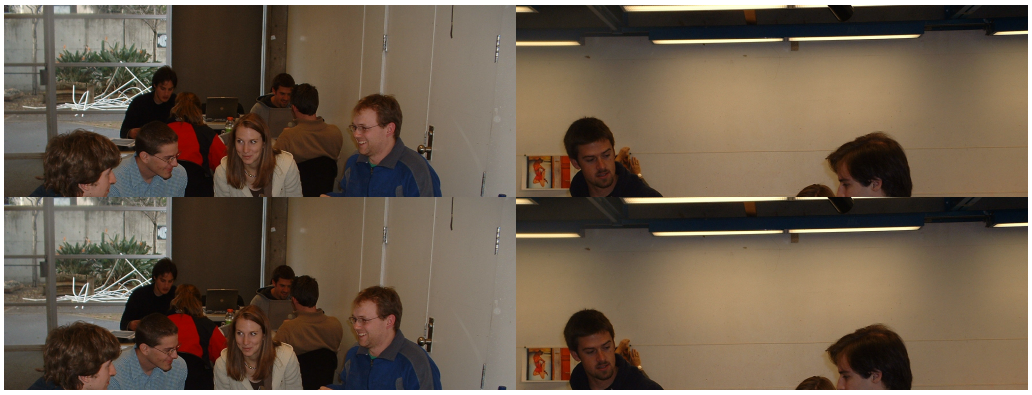
Icebreaker Activity 1

Shortly after the icebreaker activity, design teams were formed. The activity provided the instructors with information on how the students work and helped identify the strengths and weaknesses of the individuals. With this information the instructors created the design teams – two architecture students and two engineering students.

The design charettes were scheduled at the two institutions and although each meeting served to foster collaboration, each meeting accomplished different goals. After one month, the first charette was held at the engineering school and another icebreaker was conducted as a kick-off. Students were divided into larger groups, 5-6 people, to encourage dialog and partnering amongst the groups as a whole. The program had an emphasis on lateral loads and configuration in hopes of exposing the architecture students to structural systems required for seismic and wind. The students built structures using dry spaghetti and hot glue. The idea was for the engineers to describe structural principles and help define design parameters such that the architects could create something that looked "good" and could restrain a lateral force. The spaghetti structures were judged for aesthetics, popular vote amongst the participants, and for integrity, did it restrain the prescribed load. This forum allowed the students to interact in a somewhat social setting with an academic under tone which helped set the stage for the rest of the design charette.

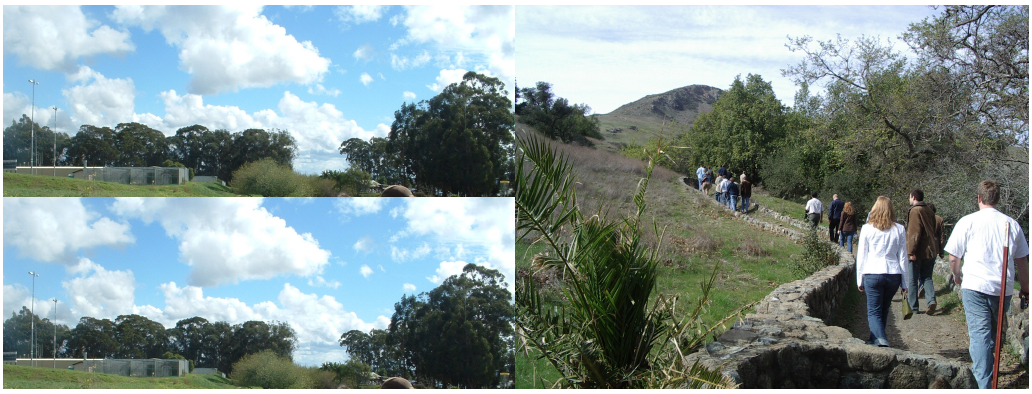
Ice Breaker Activity 2

The design team meetings at both institutions spanned two days and culminated in a project review on the third day. At the first charette, each team was required to develop and present a coordinated architectural and structural scheme for their 50 percent submission, discuss how the major design elements affected each discipline, and to outline tasks to be completed for the next phase. Most proposals, incorporated computer renderings, massing models, and of course, hand sketches. At this point in the class, students were exposed to the rigors and challenges of schematic design. They experienced how fluid and dynamic the design process can become when two associated disciplines come together to solve a common goal. And just like practice, each design team's approach changed with the give and take that occurs during negotiations and evolved into a cohesive solution that addressed both architecture and structure.



Design Charette No.1

In addition to working, students were hosts to the visiting institution. Extra curricular activities and a group dinner were planned to showcase regional attractions, but to also foster friendships. A full afternoon and evening of events were planned: from playing on the beach to playing Frisbee golf. It was a great experience for the students to learn about regional similarities and differences and become better acquainted with their counterparts in an informal setting. Both instructors agreed this sort of down time was very beneficial. We felt the students would be more open to call or write after the session if they felt comfortable with their teammates.



Team Building Activities

The second design meeting was held at the architecture school about six weeks after the first design charette. It consisted of two days of collaboration and a day of presentations to practicing architects and the two faculty members. The goal of this meeting was to better understand the engineering system and how it integrated with the architectural solution and to address detailing and connection issues. This was very important since most of the proposals exposed the structural frame as part of the design. The student meetings tended to be very productive and long. It was common for all of the groups to begin mid-morning and end after mid-night, but all of the students were satisfied with their progress and were enlightened by the process. This meeting was crucial to the success of the class. Designs were finalized but not finished and students left with a better sense of what they could and could not do within their discipline. A successful designer can communicate in very simple terms what can and can not be done without impacting the design of others. The need to clearly articulate design priorities and final design directives was a requirement of each team. This enabled each discipline to proceed onto completion. All the teams commented on the value of the last trip. The students could see there work coming to fruition and see models that integrated structure and architecture.

Communication

Between design team meetings, individuals communicated similar to the way professionals communicate in practice; electronic mail and telephone calls. And everyone agreed; these two methods of communication are useful, but were not as effective as the face to face discussions held at the design team meetings – just like practice. Communicating via e-mail and to a lesser extent telephone emphasized the importance of a clearly written letter using laymen terms to describe complex engineering principles. In retrospect, the students became teachers to one another.

Electronic mail and telephone calls are used readily in the design profession. Students learned first hand it is easiest to compose a written memo via e-mail, but it is the hardest means when trying to conduct a conversation. And while the use of a telephone lies somewhere between a well crafted letter and a person to person meeting, when they met face to face, they found the advantages of voice inflection, facial expressions, the use of props, and the ability to sketch something on the spot allowed for unparalleled efficiency and clarity.

The design meetings were a good assessment vehicle for student communication skills. It allowed them first hand results to see how there written and verbal correspondence was interpreted and included in the next phase of the design process. The design meetings also reinforced the value of meeting face to face. When the second meeting was completed, the students needed to exhibit a thorough knowledge of engineering principles so that they could describe structural behavior in simple terms that the architects would understand.

While other forms of communication are available today, such as video conferencing, the students at each campus did not have economical access to this form of communication. It is proposed that web-cams be used for future endeavors to help facilitate communication and aide students in fully understanding the design proposals in three dimensions. By adding this medium to the class, students will be able to communicate similar to video conferencing but on a more limited scale.

Scheduling

Additionally, during the design phase teams were required to meet on a weekly basis with the instructor. The purpose was to assess what had been completed and compare that to their project schedule. If the work was not on schedule, students were required to update their schedule to reflect their status to that point. As a means to emulate practice, each team defined their project deliverables and their project schedule. Part of managing a project is setting submittal dates and establishing project deliverables, by allowing each team the freedom to define submittal requirements; it reinforced independent thinking and project management skills.

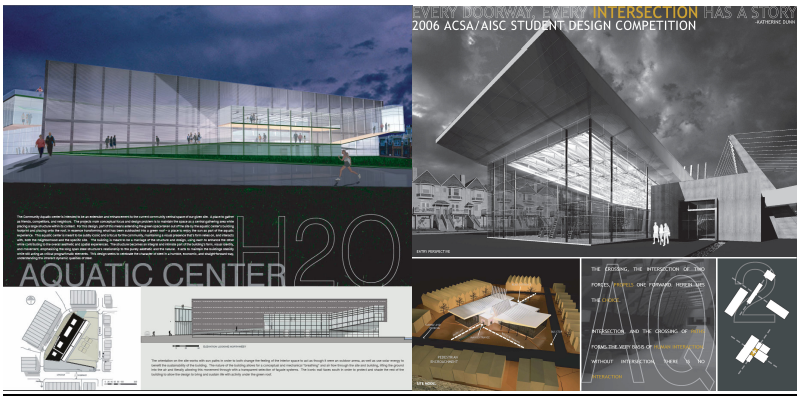
Final Submittals

Projects concluded with an oral presentation to faculty and visiting practitioners and submission of a project binder. The reviews were very productive since they allowed the students another perspective on how to solve a design and how to speak to an audience that has a broad range of engineering knowledge.

The project reviews addressed presentation skills also. The engineering review panel consisted of three licensed structural engineers, two of whom are partners at their respective firms, and the two instructors. The project reviews allowed students to describe their solutions using technical terms, but also required them to explain why certain decisions were chosen and how they impacted the space architecturally. Student presentations typically included electronic slide shows, boards, and the occasional model to emphasize the importance of a structural feature. At the end of the presentations, the reviewers typically asked the designer's if they considered additional criteria and provided other options for analyzing their project and things to be aware of should they proceed further with the project. The review process was set up like a round table session; to help inform the student designer and provide positive criticism for areas of improvement.

Like most projects, submittals included calculations and drawings. But the students were also required to document all correspondence as well. The goal was to initiate students to the total design experience and how documenting the life of a project can be crucial to the creative and

financial success of a project. The other objective was to show the students that a lot of give and take occurs through out the life of a project and to see how the project evolved in the project binder can be enlightening.

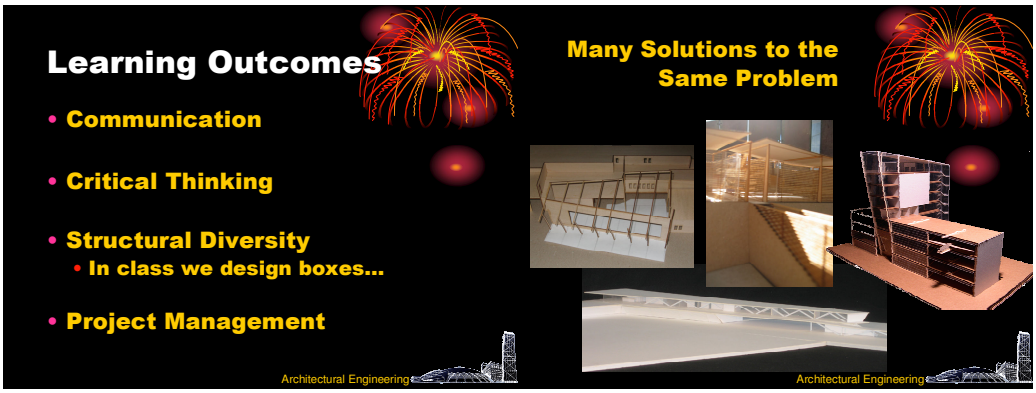


Final Submittals

Lessons Learned

Student exit surveys and practitioner feedback have been very positive. Students and practitioner's alike applaud the exposure to projects that simulate real life practice and to projects that incorporate structure and architecture holistically.

Student reviews have given both instructors' marks well above departmental averages. Students have rated the architectural course almost a five on a scale of one to five and the engineering students have given the engineering counterpart almost a four on a scale of one to four. Most of the students commented that they enrolled in the class because they wanted to be exposed to "structural diversity" or projects that were more than a box, as well as, participate in a class that stressed collaboration with architects to better prepare them for life beyond college. A student presentation was given to the dean's advisory council and a sample of the comments made by the students is shown below:



Images from student presentation to dean's council

Practitioners from both the architectural and engineering profession felt that exposing students to the nuances of negotiation, real life collaboration, and hands-on learning better prepares students for the working world. (Sample comments are included below)

Excerpt from review panel member:
As a Reviewer, I was very impressed with the quality of projects that the students at Cal-Poly San Luis Obispo are able to produce. It is clear that the courses offered at the University prepare the students with real practical knowledge and experience and not only book theory. The Departmental mission of preparing the students for the structural engineering profession can be well seen in the design collaboration, exposure to "non-box" like structures and the emphasis and importance of communications and documentation.

The project that the students participated in as part of the course was able to introduce them to real life design experience, such as interacting with other disciplines documenting etc. giving them enormous advantages over students from other Engineering programs.

Excerpt from dean in regards to comments made by the dean's advisory board which consists of practitioners from construction, architecture, landscape architecture, and structures:
"After one presentation of the student work to my Dean's Advisory Committee, several remarked that this one class might actually be the most important design lab in the upper division years for our students."

And to improve the course, webcams and earlier feed back from design professionals will be infused into the process. The webcam will enable students to better understand and coordinate complex building proposals and earlier feed back from design professionals will help the students address design issues in the beginning of the design process and resolve them collaboratively.

Exit interviews and surveys indicate that the collaborative design process was a positive and valuable experience in preparing students for the engineering/construction profession. The requirement to complete a project with an architectural team and the requirement to communicate long distance and then compare that to meeting face to face has been sited as valuable lesson and revealing nuance to the design process. It is the instructors' goal to offer this course annually and to continually build upon our lessons learned from prior steel design competitions.

Acknowledgements

Without the help and insights provided by my partner, Professor Tom Leslie, AIA, this course would not be possible. Professor Leslie's experience as a practicing architect and as an instructor at Iowa State University has been an invaluable asset in the development and success of this course.

Bibliography

1. Dong, K, Leslie, T, "Cross-Discipline, Cross-Country: A Collaborative Design Studio Integrating Architecture and Engineering". 2006 ASEE Annual Conference and Exposition Proceedings, ASEE, Chicago, June 2006.
2. Austin, S, *Design Chains: A Handbook for Integrated Collaborative Design*, Telford – Thomas Limited, March 2002