Teaching Integrated Practice in a Cross-Disciplinary Curriculum

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ABSTRACT

Fundamental shifts are occurring in the way we teach and build. The influence of digital tools, design-build frameworks, and multidisciplinary integrated project teams are affecting the way we design and deliver buildings. As the complexity and interactive communication between disciplines on projects increase it is necessary to introduce changes in the way we teach. This presentation of the Integrated Building Envelope class demonstrates methods for teaching a multidisciplinary professional elective course at Cal Poly. This elective explores how an integrated team approach can be utilized for the design and construction of sophisticated external building envelopes. The class is organized and team-taught by instructors from each of the following disciplines: architecture, architectural engineering and construction management. Choosing external building envelopes as the subject for this class allows students to focus their attention on one aspect of building design – a decision influenced by a 10 week teaching term. By focusing on the building envelope students were able to explore the design, engineering and constructability in greater detail. Lectures were given by instructors and invited guests from industry, including construction managers and cladding manufacturers, exposing the students to a variety of approaches related to the subject.

The model for this class is inspired by what is happening in industry today, where there is the need for improved collaborative design, faster product delivery, and more efficient buildings combined with more effective, transparent communication across the entire project team. Currently, research into integrated practice is being supported by professional institutes, including the American Institute of Architects and other AEC related organizations. It is imperative that the curriculum in professional programs reflect these current practices by introducing students to multidisciplinary models and emerging technologies.

The influence of pilot classes like this one are potentially far-reaching and create the opportunity of revising professional curricula, hybrid models of instruction and partnerships with industry to stay current with the needs of the real world.
2. The coming together of dynamic form with a broader application of sustainable technologies. The adaption of technologies from other industries, such as aerospace or shipbuilding creates a new framework for collaborative practice as well as efficient design, manufacturing and assembly processes.

3. Using Building Information Modeling (BIM) to create a virtual model of the building that allows for the specification and performance testing of all the components of the building before it is built. BIM also increases the dynamic communication between the members project team allowing for fast and effective feedback from each discipline in the design development process. (Friedman 2006:0)

This presentation addresses how two faculty members at Cal Poly are attempting to engage these interdisciplinary shortcomings in the typical individual AEC curricula and suggest ways of this becoming a seed of a greater strategy in linking curricula and increasing communication between departments across our College. Central to our efforts is a shared interest in the holistic approach to developing a design solution. We believe the process of making buildings is interactive among disciplines with each discipline constructively contributing to the design and efficiency of the process.

How can we teach this kind of current industry best practice integrated framework in a single disciplinary curriculum? The case study method provides the best opportunity to do so. By studying on a case-by-case basis the various frameworks of integrated project teams, there can be an effective introduction of these concepts to students. In each discipline it is possible to introduce and explore these projects in this manner, but it is not the fully integrated learning experience that we all strive for. This approach of single discipline teaching is limited, as are the traditional constructs of design-bid-build method, without project team integration. The sequential nature of this design-bid-build project framework creates a disconnection from the disciplines that are gathered for the same goal, to create a building. We feel this outdated design and building structure is no longer the only perspective that students should experience. There are new concerns that are part of the considerations for the design of a building that are more complex than the experience of people in one profession. It is becoming necessary with legislative requirements for energy, sustainability and the increasing material and labor costs require new interdisciplinary approaches to a project much earlier in the process. The preferred situation for a fully integrated project team changes the contractual basis for a project to design-build. In this scenario, the project is created by an integrated interdisciplinary team who are all working toward the same goal. The structure we suggest for teaching this class is a team of interdisciplinary instructors who can understand the unique perspectives of each profession.

Our class is structured around the concept that the instructors are also an integrated project team. This includes instructors from three disciplines; architecture, structural engineering and construction management. We combine this with a mix of students from these disciplines working on various projects that explore the issues of collaboration on a series of projects during the term. The students work as an integrated project team.

The desired structure of the learning environment involved a couple of different factors:

1. A mix of students from the three disciplines on each team
2. An effective sequence of projects to enhance the learning experience

Because of the short 10-week term structure we have at Cal Poly, it was decided that we could only effectively look at a part of a building. We both had professional experience and research interest in external cladding systems. This seemed to be the logical focus. External cladding is a complex system that each of the disciplines usually has a say in. The architect can design it and is invested in its aesthetics, the structural engineer needs to understand the design, propose effective structural supports and analyze material performance, and the construction manager wants to make it cost effective and buildable. Building envelope systems are perhaps the most scrutinized element of a building by the design team.

Our inspiration for this class was based on a framework of opportunities.

- Interdisciplinary aspect of our college allowed easy access to three departments: architecture, architectural engineering, construction management
- Having professors with extensive industry experience
- Students with a strong “learn by doing” approach to learning
- Strong connections to a regional alumni network in each discipline
- Guest lectures by people from industry
- Dean who supports interdisciplinary teaching
- Proximity to two large metropolitan areas with some excellent examples of cutting edge external envelopes
I. THE CLASS VERSION 1: ANALOG

The goal of the class were not lofty, but developed using our experience as design professional. The learning objectives can be summarized as follows:

1. Work collaboratively in a multi-discipline team
2. Synthesize architectural issues in building envelope selection, design and construction
3. Manage construction issues related to material procurement, sequencing and erection
4. Examine structural design issues related to building envelope systems, material selection and design
5. Demonstrate a fundamental understanding of human comfort issues
6. Choose the appropriate process of design and assembly for building envelope systems that integrate architecture, structure and construction

We saw the class as being a hybrid teaching environment using both lectures and project based learning to explore numerous topics related to the building skin. Three main components were developed to achieve the learning objectives:

1. Lectures and roundtables
2. The envelope analysis project
3. The envelop design project

During the first half of the term, a series of individual lectures and group round table discussions were presented by the instructors. Each instructor presented detailed information about our individual disciplines relationship to building envelopes, which created a dynamic learning environment when we participated in group round table discussions fielding questions from the other instructors and the students. Supporting these instructors’ lectures were a series of guest speakers from industry including project managers, engineers and external cladding manufacturers, who gave the students other viewpoints. While this material was being presented the students were assigned a research-based project, the envelope analysis. This analysis project required the student teams to work together to create an in-depth case study examining a single building envelope. The buildings were chosen from a short list of buildings that were accessible, having a certain degree of complexity and have a high level of aesthetic consideration. [See fig. 1] The envelope system was analyzed by each of the disciplines. The focus of the assignment was a series of three-dimensional analytical drawings that included axonometrics and cut away perspectives analyzing the envelope system and how the envelope was constructed. The drawings conveyed the elemental nature of the envelope. It was mandatory that the students visit the buildings and be able to contact one member of the design/construction team to have access to drawings, documents and first-hand knowledge of the process of creating the envelope system. The analysis process minimized speculation, seeking information from primary sources and presenting the facts in a critical manner. Completed buildings are riddled with compromises and these can only be understood by talking to people involved in the project. Stories from the construction site and designer anecdotes were required to be part of the student team presentations. Generally, the process of design and

Fig. 1 Envelope Analysis projects (top to bottom): Caltrans by Morphosis, Art Center College of Design by Daly Genik, De Young Museum by Herzog de Meuron, Metreon by SMWM
construction was asked to be reconstructed by the students enabling team members to understand the roles of their counterparts. The architects explained the design concepts and design development of the envelope, the structural engineers learned to describe the underlying engineering principles in layman’s terms and their concern about structural performance and coordination, and the construction managers discussed cost, fabrication, delivery and assembly of the envelope. Each individual discipline was asked to explain the level of integration of their discipline into the project team and how the project team was structured.

The second half of the term is devoted to the envelope design project. The student integrated design team designs, engineers and provides costing for the construction of a building envelope. Information is given to student teams for the development of a new building envelope with a scope limited by the following parameters; it is a commercial office building, document the corner condition with one face facing south, three story minimum building height, a multi-storey space is behind one face of the building. The teams are asked to prepare a design, engineer and provide construction management skills for installing the envelope system, and provide documentation of the process. The teams developed the proposals using class time for desk crits and team coordination of the team and out of class time for research and development plus more coordination. The team members participate as equals in deciding the criteria for the specifics of the envelope. Each discipline contributed their knowledge or provided research to support their ideas for the envelope design from the beginning of the project.

The student teams draw on their experience from completing the case study, information included in the lectures and stories told by the invited guests. The process for completing this assignment was similar to a design studio, with class time opportunities for desk crits with the instructors and intermediate reviews. The final reviews required the student teams to present their designs in threedimensional graphic form, a calculated structural analysis with appropriate detailing, costing breakdown and a buildability analysis that describes procurement, scheduling and installation. [See fig. 2]

As part of the final evaluation of the students’ absorption of the material we included a final exam with essay questions was administered. The questions varied from topics germane to the issue of integrated project teamwork to building envelopes to a self-reflective question for the individual student about their experiences in the class. This critical post-project reflection by the students gave the instructors direct feedback about their learning experience and an often candid assessment of their interactions as members of the integrated student teams.

Fig 2. Envelope Design Projects (top to bottom): Teams correspond to the envelope analysis projects from Fig. 1.
II. OUTCOMES AND NEXT STEPS

The strategy of developing a interdisciplinary class that was team-taught has been a successful adventure. Our goal of providing a hybrid learning framework to introduce integrated practice issues using an integrated instructor team has created an effective and dynamic learning environment. The nature of integrated practice is exemplified by the dynamic nature of interactions within the team. While the lecture topics were carefully coordinated through the term ensuring appropriate material coverage, the round-table discussions with full instructor team participation became an exercise in “thinking on your feet” in a similar way to real world situations. Questions framed by other instructors and the students were unpredictable, partially because of the interdisciplinary aspect of the course. Everyone brought their own professional inclinations and viewpoints to the table. The professional dynamic of these round table sessions was also experienced with certain guest speakers and their presentations, as the instructors acted as the team leaders. It also became evident in the desk crit sessions for the envelope design project as well. It was interesting to the instructors, that so much of what a student brings to professional practice is instilled by the educational experience, without having the real world experience of working on a project team. The questions raised by the instructors at these desk crit sessions also created a dynamic that closely mirrored the real world, with certain tensions between the disciplines coming into play. We used these moments as a learning opportunity to explore the reasons why the tension exists.

The student feedback on the class has been very positive and student evaluations support this notion. On a scale from one to four, with four being the highest, the average rating for those taking the class as a design elective is about 3.5. Because of the close collaboration on the student teams, the students developed respect for their peers and the other professions. The comments we received from the reflective question on the final exam generally had suggestions to slightly modify in the content of some of the lecture topics (i.e. more information about fastening systems) and were very positive about the guest speakers who volunteered their time. We also were given a little more first-hand information about the students experiences on the project team with both positive and negative comments about the predisposition of certain professions, which were informative and entertaining.

This class has also been instrumental in developing new lines of communication between departments and instructors. In the academic environment it is too easy to stay cloistered from events outside your realm and keep in your comfort zone. The very nature of this teaching methodology breaks one out of this. The goodwill and friendships that have developed has already sparked a number of other interdisciplinary initiatives for developing shared digital facilities and applying for grants. It is important to have cohesiveness and purpose when developing these interdisciplinary proposals, and this class has provided a focus for an integrated practice initiative across the college.

III. THE CLASS VERSION 2: DIGITAL

We are currently working on a second generation of the class that will use building information modeling as a learning tool. The emergence of BIM platforms allow this class to be a pilot class for our school to begin using this type of software. Careful attention must be paid to how the BIM tools are used in an academic setting. There are a few well-published practices that effectively use these tools and suggest that BIM can revolutionize the profession, but this technological leap should be done while considering a parallel leap in design thinking. As academics we are responsible for creating the foundations for the students lifelong learning process, which involves a different sensibility than implementing the newest technical marvel. It is true that aspects of integrated practice can be addressed at a much higher level using BIM, and being used in an interdisciplinary elective class circumvents some of the potential liabilities of using this software in an architecture-only curriculum. We must also recognize that BIM is a representation and communication tool that requires answers to be entered, while design thinking is question-driven. Balancing these issues should be a goal of an integrated practice oriented curriculum. (Cheng 2006:5) A concern that we have about BIM is the steep learning curve using BIM software and the short time frame of the class. We anticipate that the students will require extra support, just for the software. Our hope is that we can increase the level and speed of communication between the disciplines by using this tool, once the student become familiar with its capabilities.

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REFERENCES
