AC 2012-3497: INTERDISCIPLINARY CAPSTONE DESIGN: ARCHITECTS, STRUCTURAL ENGINEERS, AND CONSTRUCTION MANAGERS

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Interdisciplinary Capstone Design – Architects, Structural Engineers, Construction Managers and Landscape Architects

Abstract

The College of Architecture and Environmental Design at California Polytechnic State University in San Luis Obispo is the only college in the nation that has departments of Architecture, Architectural Engineering, Construction Management and Landscape Architecture in the same college. The institution has a 60 year tradition of collaboration between the engineering, architecture and construction disciplines, particularly at the lower division level. To enhance this collaboration, the college committed to providing an upper division, interdisciplinary experience to every student in the form of a project based, team oriented five unit studio laboratory that every student would take. The course is now in its third year and requires small teams of architecture, engineering, construction and landscape architecture students to complete the schematic level design of an actual building for a real client.

The challenges in creating and executing such a course fall into three major areas: institutional, logistical and pedagogical. Institutional issues include university support and concurrence from four different department heads. Logistical issues range from finding open time within the four schedules to offer the course and securing physical locations for small and large group meeting areas to the seemingly mundane tasks of ensuring all students are in the correct location and finding common times for the instructors to meet. Pedagogically, the course needs a unified and integrated approach that must be agreed to and implemented by all professors. Traditionally professors work as individuals and team teaching of this magnitude is a paradigm shift that requires significant time, a flexible mindset and a commitment to collaborate.

This paper reports on the progress of this course using survey assessment data and direct performance indicators. These same data provide valuable support to the 3 a-k ABET program criteria. The variety of projects undertaken to date illustrates the flexibility of this course. The paper describes how the challenges listed above have been overcome particularly concerning the role of the faculty in the course and the merging of very different department cultures. Finally, the future of the course and the suggested improvements are highlighted.

Introduction

The College of Architecture and Environmental Design at California Polytechnic State University in San Luis Obispo is unique in the nation in that it contains departments of Architecture (ARCH), Architectural Engineering (ARCE), Construction Management (CM) and Landscape Architecture (LA) in the same college. With this assembly of architectural, landscape architecture, construction and engineering disciplines the college has been able to build a 60 year tradition of collaboration between those disciplines.

Through most of its 60 year history, this collaboration has largely occurred in lower division classes. To build on the philosophy of interdisciplinary collaboration and also to reflect recent trends in industry, CAED launched a senior level interdisciplinary course in 2009 that integrated the ARCH, ARCE, CM and LA students into a single course utilizing real projects with real clients. The course faced immediate challenges in three major areas: institutional, logistical and pedagogical. Previous papers[1,2,3] have chronicled these challenges in detail. This paper provides an update on this unique capstone interdisciplinary experience, provides the latest assessment data, and suggests improvements for the future.

Course Description

The course (ARCE 415, ARCH 451, CM 415 or LA 405) Interdisciplinary Project Delivery is an upper-division, project based, five unit interdisciplinary studio laboratory that meets for three days a week with core hours of 1:00 – 5:00 pm. The projects are different every quarter, typically have had little or no previous design work, are geographically close enough for student visits, have an identified client or clients who can participate in the course and have sufficient scope to challenge each of the four disciplines. The course has evolved into one with a target enrollment of 72 students from four disciplines, ARCE, ARCH, CM and LA. It is team taught by four faculty members representing each of these same four disciplines with the class divided into small interdisciplinary student teams, typically twelve teams of approximately six students each. Ideally each team contains one or two architecture, one architectural engineering, two construction management and one or two landscape architecture students. The course has three major milestone submittals, each one with an oral presentation and a printed submittal.

Institutional Challenges

Department Head Commitment. The department heads were important in the initial implementation of the course. Their commitment was critical to bringing all four departments together, establishing the number of units, coordinating schedules, selecting faculty and making the necessary curriculum changes. As the course matured, the department head role has evolved to assessing progress, providing required resources and brokering solutions that make such a course work for all departments. While the department heads have not driven course content, they have met with the faculty members regularly. Because the course is so expensive in terms of instructor hours, the biggest challenge has been managing enrollment and providing resources during tough budgetary times.

Course Format. Determining a common course format acceptable to all departments proved an initial challenge. A key question was the size or number of units of the proposed course as the course had to fit into each department's existing curriculum. Because ABET accreditation criterion 3d for engineering programs[4] requires that every student be able to function on multi-disciplinary teams, a large enrollment default course was needed. A five unit studio laboratory during a single quarter was ultimately chosen

for the new course for a variety of reasons[2]. The decision was more difficult for the ARCE department due to a highly impacted curriculum composed of typically three unit courses. This has been addressed by having the new interdisciplinary course replace a prior three unit "senior project" course. The additional two units were gained by concurrent curriculum changes. There still remains a lingering question among the ARCE faculty as to whether there is sufficient engineering content to justify a five unit studio within the very impacted curriculum. In the current third year offering of the course in a five unit format, this question persists among the ARCE faculty and there has been discussion of reducing it to a four unit course. Landscape Architecture joined the course after the other three departments at a slightly reduced level with four units.

Faculty Assignments - It was quickly determined that a faculty position from each discipline would be needed nearly full time to implement the course. Faculty members assigned to the course typically have some practice background allowing the course to more closely mirror an industry interdisciplinary project experience but the departments have taken different approaches. ARCH and LA have chosen tenured professors, CM an untenured faculty member and ARCE a rotation of several faculty members. The ARCH, CM and LA faculty members have taught as a group for almost two years and provide continuity. The approach of rotating ARCE faculty members benefits the ARCE faculty by keeping them better integrated with their department and benefits the course by bringing a variety of ideas and approaches to the course. However it reduces the ability of individual ARCE faculty members to effect long-term changes to the course. The course serves roughly 220 students per year, however the distribution by department has not been uniform. In some quarters, there have been as many as three CM students for one ARCE student. This has resulted in a course that is more expensive for some departments.

Logistical Issues

Class Room Facilities – The course requires a teaching space or spaces that can accommodate a range of student group sizes varying from private mentoring sessions with two or three students to large scale public lectures for the entire class of 72 students. As the course has evolved, a need for three different types of classrooms has developed.

Several adjacent classrooms in a new building were designed for and specifically dedicated to this new upper division interdisciplinary course. The classroom facilities have worked very well for student work areas. Each student team of six interdisciplinary students is assigned a team work station.

As part of each classroom, there is a faculty ready room where faculty can meet together or with a small group of students. This faculty ready room has been a great benefit for privately mentoring small groups of students and for private faculty discussions related to the development of the course.

Lectures given to the entire class of 72 students have been delivered in a larger adjacent lecture hall scheduled for that purpose for the first portion of the class. Each of the four

disciplines has used breakout sessions, on a formal or informal basis, to provide additional discipline specific content. These breakout sessions either use the large lecture hall, when available, or are scheduled in individual departments' facilities.

Pedagogical Issues

Many pedagogical issues were faced in the development of the course. These included the development of learning objectives, a teaching approach, a grading rubric and the selection of class projects. These efforts have been largely successful based on observations by the faculty and course assessment data. However there are still improvements that can be made.

Teaching Approach. One of the challenges of the course is that the four departments have different teaching cultures. For example, the ARCE Department uses a strong lecture format with focused assignments and projects that provide examples of the technical content. The Architecture Department uses a studio approach centered on projects where students are given guidelines and encouraged to explore and create. The course has settled on a format using a combination of approaches.

General lectures are given to the entire group of 72 students from all disciplines in a large lecture room. These lectures are generally of two types. Some provide information directly related to the project. They provide project and assignment information as well as general reviews of submittals and other project assignments. Other lectures present technical information of interest to all students. These technical lectures have been on topics such as historic preservation, life safety code requirements, cost estimating, structural systems and underground construction issues. Lectures have also sometimes been made on practice topics such as presentation skills and project management. Because these lectures are presented to the entire class, the content must be appropriate for the non-major students who will make up the majority of the audience. Necessarily, the content will be a review for some students. For example, a lecture on structural systems would be targeted to architecture and construction management students but would be largely a review for architectural engineering students. The faculty considers this appropriate because it provides a common level of understanding for the students allowing them to communicate with each other on critical aspects of the project.

In addition to the general lectures, discipline specific lectures are given to students from each discipline and are more detailed and technical in nature. The lectures may be reviews of topics already covered in the discipline's curriculum. They may also be on new topics relevant to the project. These are made in discipline specific breakout sessions.

One ARCE lecture topic is conceptual structural design. The ARCE curriculum is excellent at educating students in fundamental structural principles and the application of those principles for a comprehensive final engineering design of structures. This education prepares students well to become professional engineers developing final engineering designs after the basic project concept has been established. However, the

current curriculum provides architectural engineering students with limited preparation to participate in the early conceptual design stages of a project with their fellow ARCH and CM peers. The breakout lectures on conceptual structural design help remedy this.

Other ARCE lecture topics have included the seismic assessment and upgrade of existing buildings and advanced superstructure and foundation systems. Because of time constraints, these topics are not covered in the depth they would be in courses devoted entirely to the topics. Their focus is to provide students with an understanding of concepts, implications, advantages and disadvantages and the tools needed to prepare the conceptual designs that are required for the course project. CM students receive lectures in topics such as the use of cost estimating software and conceptual cost estimating.

These lectures, overall and discipline specific, provide important course content, however the course format is primarily that of a studio. The faculty has therefore limited the durations of lectures to provide the students sufficient time to work in teams on the projects. The frequency of lectures declines toward the end of the quarter as the students concentrate on the production of their presentations and submittal documents.

Instruction occurs in other ways as well. Mentoring between faculty and students occurs in both formal and informal ways. Informal mentoring occurs with project specific questions and discussions. Formal mentoring occurs during faculty reviews of each team's project submittals. In addition, education occurs between the students. Students from each discipline bring a great deal of technical background that is shared during the project design process. As the role of the faculty members switches from lecturer to subject master expert, to mentor, to facilitator of team progress, the faculty member needs to be more versatile than in a more traditional course.

Learning Objectives. The course learning objectives are common for all four disciplines. They have evolved since the course's creation based on the instructors' experience with the course. However two primary objectives have remained: creation of an interdisciplinary design and functioning effectively on interdisciplinary teams. The current and more detailed learning objectives are:

1. **Create an integrated building design that includes a sound project approach (scope/budget/quality & constructability) including land-use, site development, architectural vision, space planning, and the integration/synthesis of building systems,**
    a. Apply and balance real world constraints in the development of the building concept.
    b. Select and configure appropriate building systems based on the constraints and interdisciplinary criteria: (structural, mechanical, electrical, civil, exterior cladding).
    c. Use current industry-standard tools and technologies in the creation and presentation of a team generated design including verbal, graphic and digital presentations.

d. Estimate the consequences of design decisions on social, cultural and environmental decisions.

2. **Function effectively on an interdisciplinary team:**
    a. Communicate effectively utilizing verbal, written and graphical methods
    b. Integrate standards of professional and ethical responsibility into the working classroom relationships and the development of the integrated design.
    c. Apply the basic project management skills of team dynamics and decision-making strategies.

The course content and teaching approach address both of these two learning objectives, but to different degrees.

The first learning objective, creation of an integrated building design, has received more attention in the instruction and the assessments show that the course has been very successful in meeting this goal. The large and small lectures, described in the previous section are typically on technical topics and the students incorporate this material in their projects. In addition, as is seen in the Grading section of this paper, the majority of the grading reflects the building design and construction.

The second learning objective, function effectively on an interdisciplinary team, has been addressed to a lesser extent. A lecture on personality types and the consideration of personality types in the formation of student teams provided some basis for discussions on teamwork. Some quarters have included lectures on teamwork and project management. In the most recent class, there was a requirement to submit a "Work Plan" listing tasks, responsibilities and completion dates. This was a start, but adherence has not been enforced or graded. An effort, in Spring quarter 2011, to enforce early coordination of architecture floor plans and structural systems was successful but received less emphasis in Fall quarter 2011. In end-of-course student evaluations, students express enthusiasm for the team aspect of the course, but many also express frustration that project designs continued to evolve up until the submittal due dates placing an additional burden on architectural engineering and construction management students whose work relied on completion of their teammate's designs. Although this of course occurs in private practice, there are real implications and penalties in private practice that have not yet been incorporated into this course. A future improvement would be additional instruction and assessment on this topic.

Grading. A grading rubric has been created that is both acceptable to the multiple faculty members and department cultures, balances the assessment of individual and team performance and generally measures achievement of the learning objectives.

Individual professors bring varying expectations and emphasis to the course. They have differing views of the importance of design versus technical content, presentations versus printed submittals and text versus graphic material. Each instructor tends to focus on his

or her discipline. The same professors also bring differing expectations that affect the distribution of grades.

The issue of individual versus team performance on each student's grade is perhaps more important and harder to resolve. Students are assigned to teams and so a student may be helped or hurt by a team assignment that is not of his or her making. In addition, because each individual student brings specific discipline expertise to the team, a single poorly performing student can have a large effect on a team's grade. The other side is that effective functioning on a team is one of the learning objectives and each student has a responsibility to facilitate good team performance.

Assessment of how well the two learning objectives, creation of an interdisciplinary design and functioning on integrated teams, are achieved should also be addressed by the grading rubric.

A simple grading rubric has been created that largely addresses these issues. There are three team submittals, P1, P2 and P3. These account for 10%, 20% and 40%, respectively, or a total of 70% of each student's grade. The grading of each submittal has a breakdown that includes scores for various aspects of the team's presentation and written submittal. This grading rubric is reviewed by the four faculty members before each submittal and a consensus reached as to the categories and emphasis. Each faculty member may grade any or all of the teams' presentations and submittals. The faculty member scores are averaged and used for the team grade. A sample grading rubric, for the final submittal in Fall quarter 2011, is shown in Figure 1.

P3 Submittal / Presentation

Submittal	Weight
3.1, 2 Letter and TOC	10
3.3 Executive Summary	5
3.4 Respondent's Qual's	10
3.5 JV Proposal	30
3.6 Project Overview	25
3.7 Conceptual Design	120
3.8 Cost Model	25
3.9 Project Schedule	25
Overall Merit	50
Submittal Total	300

Presentation	Weight
Introduction	5
Delivery Style	10
Graphical Quality	20
Content Quality	20
Q + A	10
Overall Merit	25
Presentation Total	100
P3 Total Score	400

Figure 1 Sample Grading Rubric

The category with the highest value is “Conceptual Design”. This category covers the following items:

- Site plan showing hardscape, planting, lighting, grading and detailed entrance design.
- Floor plans showing room and space information, coordination with site and vertical structure.
- Site/building sections and 3D representations.
- Exterior elevations.
- Structural foundations and floor plans.

The remaining 30% of the grade is based on individual assignments. For the ARCE students the individual assignments include homework and submittal calculation packages. This 70/30 split has two effects. One is that each faculty member can ensure that there is an appropriate level of discipline specific technical material for which the student is responsible. The other is that although there is an overall emphasis on each team’s performance, a significant portion of each student’s grade remains on individual performance. Final student grades in the course are the purview of the professor in the student’s discipline. Final ARCE grades, for example, are assigned by the ARCE professor teaching the course.

Student Teams. The students in the class are divided into small teams. Generally the 72 students are placed into 12 teams although this varies with the class size and the distribution of disciplines. Team assignments are made by faculty based on several considerations. Ideally each student team is composed of one or two ARCH, one ARCE, two CM and one or two LA students so that the four disciplines are adequately covered. Students take personality tests and teams are assembled to create a diversity of personality types in each team. There is also an attempt to accommodate student requests.

Projects. The projects have been different every quarter. They typically have had little or no previous design work, are geographically close enough for student visits, have an identified client or clients who can participate in the course and have sufficient scope to challenge each of the four disciplines.

The projects selected for the course have included a new botanical garden with a 60,000 square foot visitor center, the transformation of an 8,000 square foot unreinforced masonry building into a modern state-of-the-art building and a new 1,000 square foot residence in New Orleans for a green building competition. The projects for the two most recent quarters have been especially large and complex.

One was a new facility for the College of Creative Studies at a nearby university. It included approximately 60,000 square feet of new classroom and office construction, 200 spaces of new parking and associated site work. The client role was played by two people, the Dean of the College and a senior campus planner. They made initial presentations to the students and participated in all three presentations. Images from the

final submittals of two teams, Figures 2 and 3, show the variety of design approaches and the professional quality of the work.

The Fall 2011 project was for the athletic department on our college campus. It included approximately 100,000 square feet of new classroom, office, training and locker room construction, a 1,000 space parking structure, a 15,000 seat stadium, the renovation of two existing structures and associated sitework. The client role this quarter came from the Athletic Director and two assistants. They presented to the students, provided program information and participated in all three presentations. This last project was sufficiently large that each team took on one-half of the scope and pairs of teams collaborated in a joint venture arrangement. These last two projects probably set an upper limit on the size and complexity that can be produced in a 10 week quarter.

The projects for the last seven quarters are summarized below:

- Creation of a 30,000 sf iconic Botanical Gardens that houses meeting rooms, theaters, banquet areas, classrooms and support areas.
- Renovation of a 1937 vintage, 8000 sf unreinforced masonry building and the construction of a 10,000 sf building for an Historical Archive Complex
- Green Building Competition - 1,000 sf residences in New Orleans, $100,000 budget, sustainable and accessible with the main floors elevated above the maximum predicted flood levels
- Sedgewick Nature Reserves
- Crandall Gymnasium & Natatorium - Redevelopment of a 1927 gymnasium and adjacent 1937 natatorium into a state of the art digital fabrication center.
- UCSB College of Creative Studies – 60,000 sf building(s), parking, site work
- Athletic Department Complex – 100,000 sf building(s), 1,000 car parking structure, 15,000 seat stadium, building renovations, sitework

Figure 2 UCSB College of Creative Studies – Team EMI Design

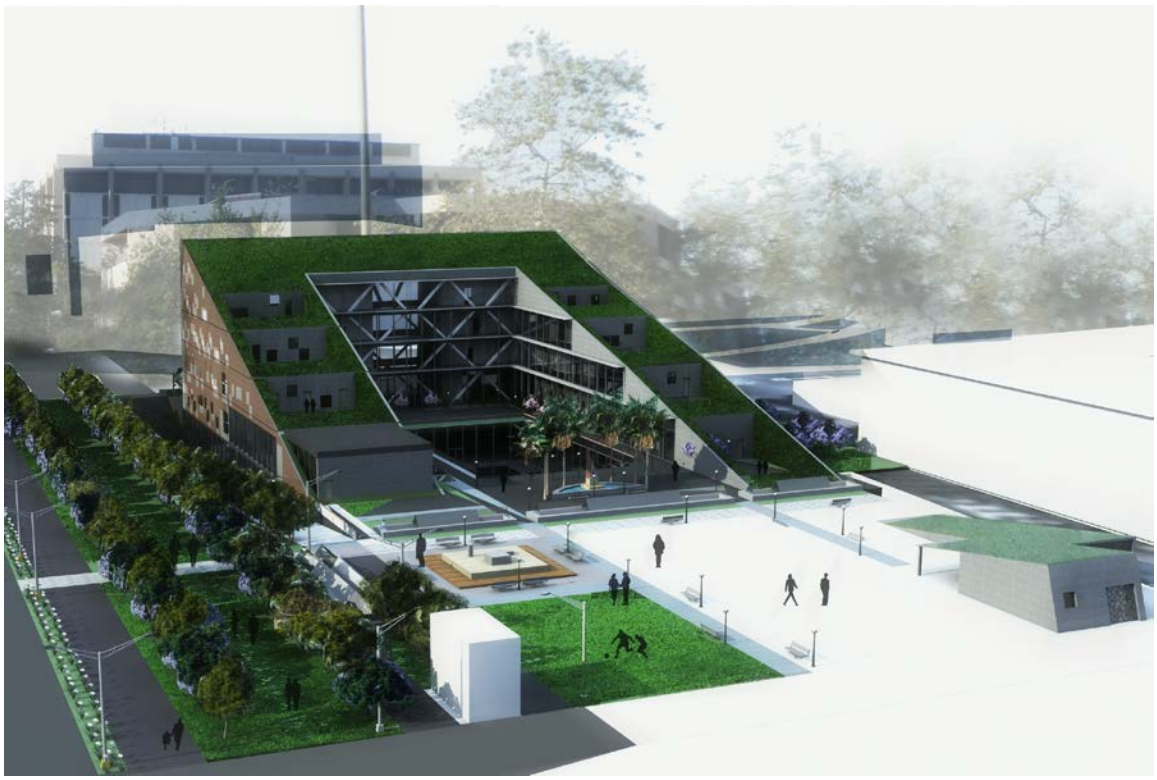


Figure 3 UCSB College of Creative Studies – Team Larch Design

Although challenging to the students, the projects are exciting and are comparable in complexity to those the students will undertake in practice. For many students, these projects present an appropriately complex culminating experience. Another important aspect is the presence of an actual client for each project. The class has been fortunate to engage clients that provide programs, overall goals and visions and attend the three project presentations by each team. The clients have made useful and sometimes blunt comments that supplement those of the instructors. Students have observed that individual client representatives sometimes have contradictory views and sometimes change the scope of the project. This is a valuable lesson. A suggestion for the future is to invite experienced practitioners to participate in project reviews. They could bring new perspectives and might carry significant weight with the students.

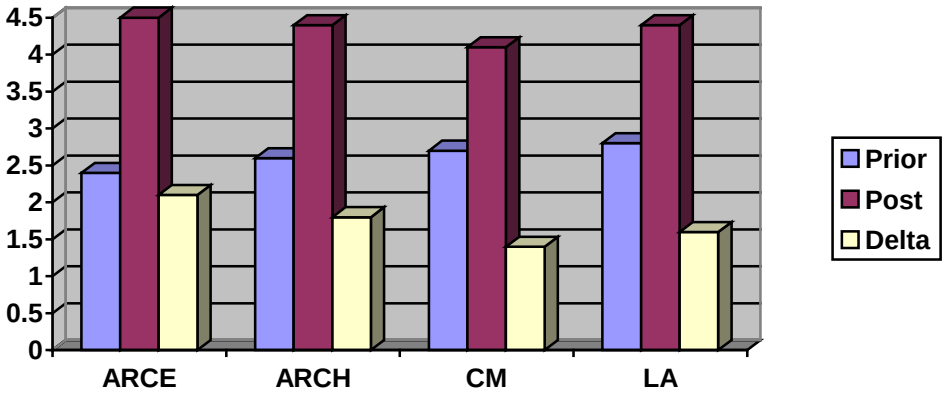
Course Assessment

Success at achieving the learning objectives has been assessed in using two methods: student course evaluations and faculty grading. These are described below.

Student Course Evaluations. Student course evaluations have now been collected for seven quarters. Each student assesses his/her abilities relative to the two Learning

Objectives and to Knowledge of Non-major Disciplines. The students are surveyed prior to entering the course and upon completion of the course on a scale of 1 to 5, with a score of 1 being little or no understanding and a score of 5 being a thorough understanding.

The results relative to the Learning Objectives presented in this paper in Figures 4 and 5, are from student evaluations collected in Fall 2011. They are also compared with evaluation results from a previous paper[2].

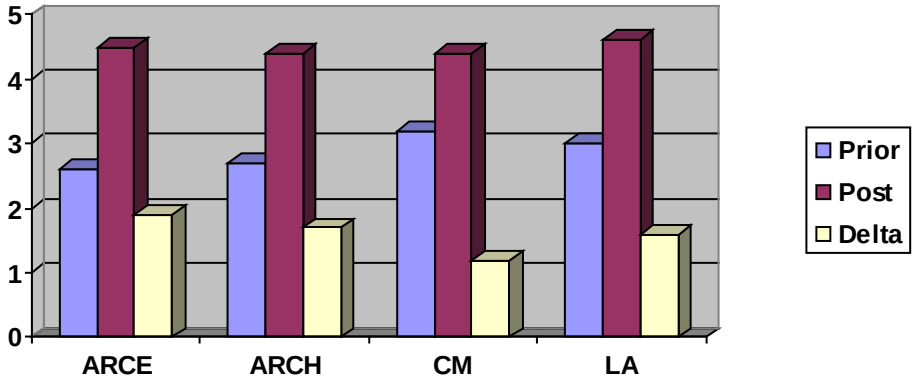


ARCE	ARCH	CM	LA	
2.7	2.2	2.9	2.9	Prior
4.5	4.4	4.4	4.6	Post
1.8	2.2	1.5	1.7	Delta

Figure 4 Assessment of Learning Objective 1

The assessment for Learning Objective 1**,** Create An Integrated Building Design, shows a consistent increase in student self assessments for all disciplines with an average improvement for all disciplines of 1.8/5.0. Prior to the course CM and LA students appeared generally more confident in their abilities to create an integrated design than ARCH and ARCE students. However students from all disciplines achieved a similar high level of confidence by the end of the course.

These results are similar to data previously reported[2]. In the previous study, student self-assessments also improved for all disciplines with an average for all disciplines of 1.6/5.0. This represents a small increase in improvement in a year and was consistent across all disciplines. Both results reveal that CM and LA students reported a higher confidence prior to the course and all disciplines reported a similar high level of confidence by the end of the course.



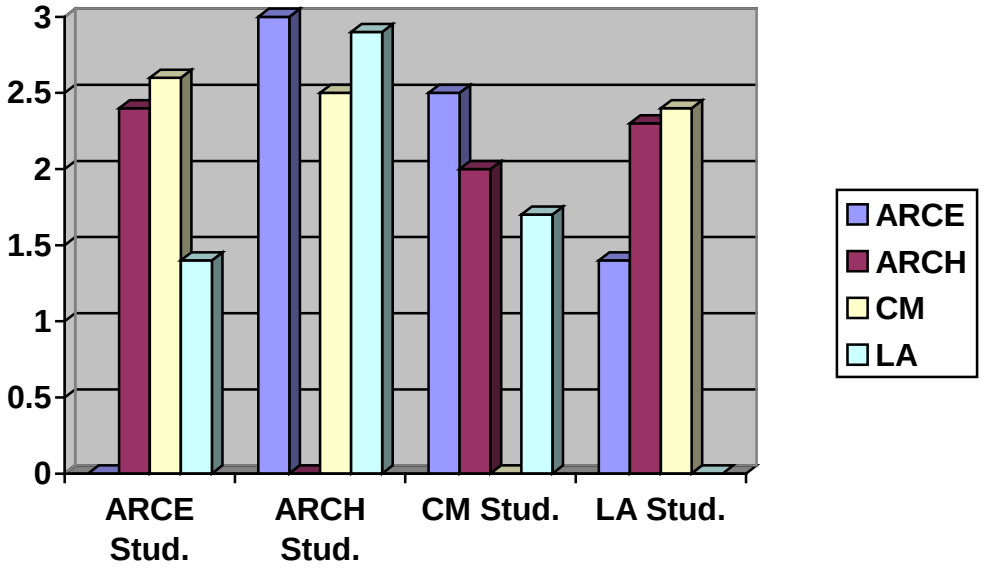
ARCE	ARCH	CM	LA	
3.0	2.1	3.4	2.9	Prior
4.5	4.4	4.5	4.8	Post
1.5	2.3	1.1	1.9	Delta

Figure 5 Assessment of Learning Objective 2

The assessment for Learning Objective 2**,** Function Effectively on an Interdisciplinary Team, shows a consistent increase in student self assessments for all disciplines with an average improvement for all disciplines of 1.7/5.0. Prior to the course CM students appeared generally more confident in their abilities to function on an interdisciplinary team than other students. Just as with Learning Objective 1 assessment results, students from all disciplines achieved a similar high level of confidence by the end of the course.

These results are similar to data from previous quarters[2] where student self-assessments also improved for all disciplines with an average for all disciplines of 1.2/5.0. This appears to represent a significant increase in improvement in a year and was consistent across all disciplines. Data from the earlier quarters[2] showed that CM students reported a higher confidence prior to the course and all disciplines reported a high level of confidence by the end of the course.

Students were also asked to assess their knowledge of disciplines other than their major prior to the course and after the course on a scale of 1 to 5, with a score of 1 being little or no understanding and a score of 5 being a thorough understanding. The results presented in this paper in Figure 6, are from student evaluations collected in Fall 2011. They are also compared with evaluation results from a previous effort [2].



	Prior to Course	After Course	Delta	Prior to Course	After Course	Delta
Discipline	**ARCE Students**			**ARCH Students**		
ARCE	--	--	--	3.0	3.9	+0.9
ARCH	2.4	3.5	+1.1	--	--	--
CM	2.6	3.7	+1.1	2.5	3.3	+0.8
LA	1.4	3.0	+1.5	2.9	3.8	+0.9
	LA Students			**CM Students**		
ARCE	1.4	2.8	+1.4	2.5	3.3	+0.8
ARCH	2.3	3.7	+1.4	2.0	3.4	+1.4
CM	2.4	3.9	+1.5	--	--	--
LA	--	--	--	1.7	3.2	+1.5

Figure 6 Assessment of Knowledge of Non-Major Discipline

Figure 6 presents the increase in knowledge from prior to the end of the course. The data show that all students left the class with a greater understanding of the other disciplines. The average increase was 1.2 points, however with significant variation that reflects the curriculums for the four disciplines. ARCE students take three lower division architectural studio course as well as several construction management courses. ARCH and CM students take an ARCE five course structural engineering sequence. It is therefore not surprising that ARCH and CM students had a high knowledge of ARCE

prior to the course or that ARCE students entered with a high knowledge of ARCH and CM. The lowest scores were for ARCE student knowledge of LA and LA student knowledge of ARCE. These two disciplines are the most dissimilar of those represented in the course. Other than general education requirements, the two majors do not have a single course in common.

Student assessment of team functioning has occurred in two other ways. A survey was distributed to students during one quarter and students were asked to respond to questions on a scale of 1 to 5. The results are plotted in Figure 7. Team functioning has also been assessed by end-of-class qualitative student peer assessments. A future improvement would be to implement these types of student assessments on a more comprehensive basis.

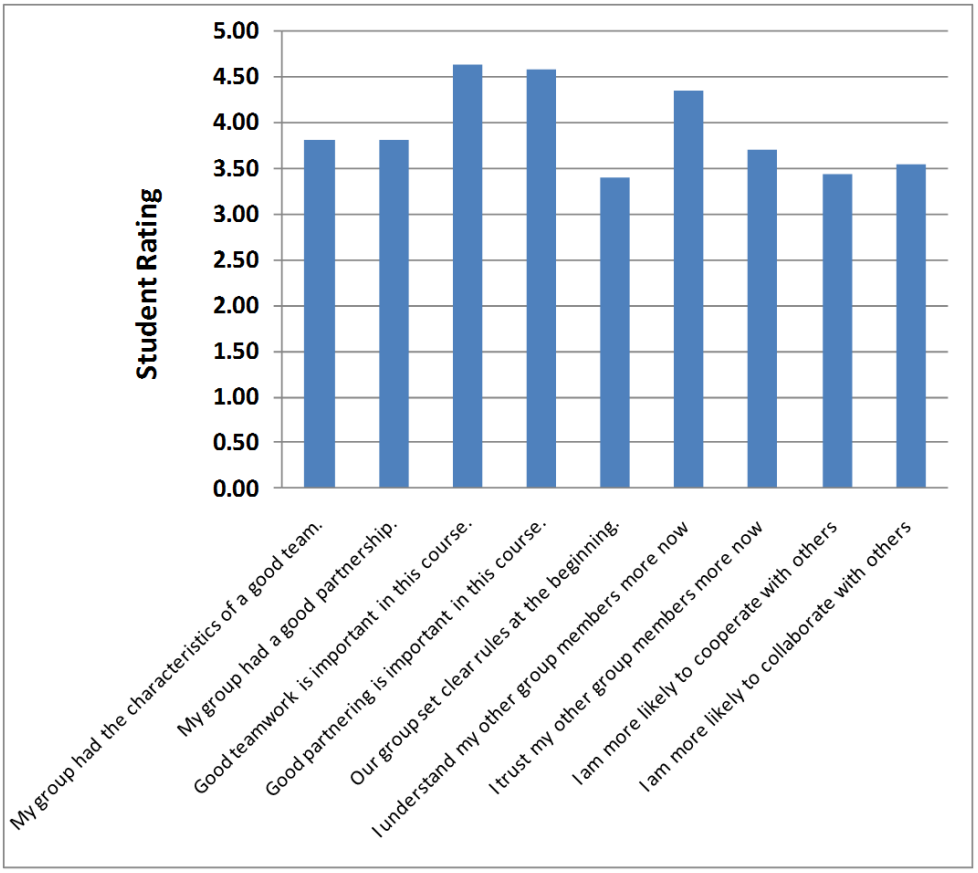


Figure 7 Student Teamwork Survey

Student Comments. Student comments were generally favorable and focused on the positive aspects of working with other disciplines and on real projects with real clients. Areas that the students felt needed improvement were the balance of lecture time versus work time, conflicting professor directions, unclear submittal requirements and difficulty in scheduling team work outside of the class hours. However the most common complaints were in the area of the team interaction. Although students almost uniformly

stated that one of the best things about the class was working on the project as an interdisciplinary team, they also complained that some team members did not complete their assignments, or that designers didn't completing their designs in time for others to do their work in a reasonable way or that students behaved in an unprofessional manner.

Faculty Assessment. Faculty grading was used as a direct indicator of students' success in achieving the course learning objectives. This was done by pairing lines from the grading rubric with the different learning objectives, where possible. As stated in the Grading section, the grading rubric does not contain lines that explicitly address most of the second learning objective. Figure 8 tabulates this pairing and the average of the scores assigned for the Fall 2011 Final Project.

Faculty Assessment		
Course Learning Objective	**Grading Rubric Line**	**Score Average/(Range)**
1. Create an integrated design that includes a sound project approach.		
a. Apply and balance real world constraints in the development of the building concept.	3.7 Conceptual Design	**90 (87 to 95)**
b. Select and configure appropriate systems based on the project constraints and interdisciplinary criteria: (structural, mechanical, electrical, civil, exterior cladding)	3.7 Conceptual Design	**90 (87 to 95)**
c. Use current industry standard tools and technologies in the creation and presentation of a team generated design including verbal, graphic and digital presentations.	Graphical Quality	**91 (87 to 95)**
d. Estimate the consequences of design decisions on social, cultural and environmental systems.	Sustainability/LEED (Spring 2011)	**88 (60 to 98)**
2. Function effectively on an interdisciplinary team		
a. Communicate effectively by utilizing verbal, written and graphical methods.	Graphical Quality	**91 (87 to 95)**
b. Integrate standards of professional and ethical responsibility into the working classroom relationships and the development of the integrated design.	None	**None**
c. Apply basic project management skills of team dynamics (personal interactions and skill sets) and decision making strategies (communication types, negotiations)	None	**None**

Figure 8 Faculty Assessment

The scores for the first Learning Objective are high, indicating that the teams generally met the expectations of the faculty. However there was no direct faculty assessment relative to the second Learning Objective. This should be reviewed in the future with faculty assigned scores for teamwork and project management performance.

Conclusion

The college faced significant challenges in creating this high-enrollment, upper-division, studio-based, project-oriented course, including institutional, logistical and pedagogical issues. The changes in curriculum required to implement this course are over and many of these have been successfully resolved. There is a consensus on teaching approach, learning objectives, grading and projects. The student teams consistently produce high quality submittals. However although students overwhelmingly state that one of the best things about the course is the interdisciplinary team experience, they also express frustrations that teams and team members often do not perform as well as they could.

Suggested improvements to the course are described below:

- Increased faculty emphasis on teamwork and project management in both class content and grading. This should improve student teamwork, enhancing those skills and improving the student's experience.
- Create more assessment tools focused on teamwork and project management. The assessment of team performance needs to be built into the grading rubric. There need to be some class exercises that deliberately address team work and provide some direct measurement indicators of performance. This would allow faculty members to make assessments and have a basis for making changes.
- Engage practitioner reviewers, adding new perspectives and publicizing the course. The students currently make all presentations to the client and to the instructors. Receiving feedback from senior level practitioners from the firms that will ultimately hire the students will raise both the visibility and the quality of this course.
- Increase advancement efforts to support this course. This effort is expensive in terms of faculty hours, reproduction costs, travel to project sites, and software requirements. The course is also a unique and collaborative interdisciplinary experience that appeals greatly to industry. There is opportunity to seek financial support from both industry partners and the clients whose projects are developed.
- Communicate the benefits of the course to create more enthusiasm amongst students and faculty. There is still some skepticism from faculty members and students that will only be overcome with time, word of mouth endorsement and improvements in the course.

These measures should make for an improved experience for the students, improve the quality of the student projects and better prepare them for an industry that increasingly values collaboration.

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