Enhancing Student Learning through Team Projects in a Reinforced Concrete Design Class

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Abstract

Project-based education has recently been incorporated into the first undergraduate reinforced concrete design class at California State University, Sacramento (CSUS) to enhance student learning. Students participate in diverse open-ended projects that challenge them to work in small groups to address a contemporary issue in structural concrete. Projects during the first four semesters typically fell into one or more of the following four areas: design, construction; materials, and research/testing. This approach to project-based education has generated significant student initiative, practical learning, and excitement.

This paper summarizes key features of team projects, including: advantages related to student learning and fulfillment of ABET criteria; design project concept; teammate and project selection; project proposals; project execution; oral presentations; formal reports; and teammate grading. In addition, student response and faculty challenges to implementing team project are addressed. Excerpts from project guidelines, a summary of project topics, and slides of team presentations are also provided.

A. Introduction

Project-based education has recently been incorporated into the first undergraduate reinforced concrete design class at California State University, Sacramento (CSUS) through the introduction of a major team design project. Project-based education was implemented to improve student learning and to fulfill many ABET criteria not normally addressed in such a class. Project-based education is known to improve student learning by increasing relevance, student motivation, active learning, the level of reasoning, and the balance of concrete and abstract information. In addition, studies have shown that the use of team projects enhances cooperative learning, including positive dependence, individual accountability, face-to-face promotive interaction, and interpersonal and teamwork skills, thereby improving achievement, persistence, and attitudes.¹

At present, most structural engineering design courses address very few aspects of Criterion 3 of the ABET 2002-2003 Criteria.² Typical classes help develop a student’s ability to apply knowledge of Math, Science, and Engineering and to design a component, and most require the use of techniques, skills, and modern engineering tools necessary for engineering practice. However, surprisingly few classes help students develop abilities to: design a structural component in the realistic context of a structural system; solve practical engineering problems; know contemporary issues; function on teams; communicate effectively; design and conduct experiments; understand professional and ethical responsibility; understand the impact of
engineering solutions in a global and societal context; and recognize the need for, and have an ability to, engage in life-long learning. In addition, few involve interaction with engineering design and construction professionals.

Many engineering programs count on the capstone design class to address these important criteria. However, implementing a suitable project in a design class improves student learning and allows students to develop abilities and understanding in accordance with ABET expectations. Thus, such a project-based course can serve as a bridge to the capstone design class.

Overview of Team Project

To take advantage of these benefits, a team project has been developed over the past four semesters at CSUS. The project requires students to participate in diverse projects that challenge students to work in typically two- to three-person teams to address a contemporary issue in structural concrete. The project counts 25% of the course grade.

At the beginning of the 15-week semester, each student is provided a set of four guidelines for the overall project, proposal, presentation, and report. By the second week of class, students group themselves into teams and determine their general project topic using the general project guidelines or select a project from a list of suggested topics. Teams then gather background information to determine their specific project emphasis and scope. Interaction with practicing professionals and the instructor is an important part of the process. By Week 4, teams submit a project proposal and, within a week, receive feedback from the instructor. Teams then use the following nine weeks to execute their project and to prepare a presentation and report. A status report is submitted during Week 11. During the final week of class, teams present project results in a formal oral presentation and submit a formal report with calculations. The following sections detail the features of the project, from selection of teammates and a project to submission of the formal report.

II. Selection of Teammates and Project

Teammate Selection

On the first day of class, students are informed that a major component of their learning involves participation on a team design project. The class is also shown slides from previous semesters’ presentations to help clarify project expectations. In addition, students are given a set of detailed guidelines for the project. Typically, students begin searching for teammates right after the first class. By the second week of class, students group together in 2-4 person teams and begin to determine their project topic. Guidelines instruct students to assign roles for each teammate, such as group leader and individuals responsible for each deliverable. To encourage full participation of all team members, students are informed that, at the end of the semester, all team members will confidentially grade themselves and their teammates in writing, based on team contributions, and that project grades will reflect this grading. Guidelines also note that the instructor may make adjustments to balance out the teams if necessary, though this has not been necessary to date.
Project Selection

During the first four weeks of the semester, teams decide on a project. Two approaches have been used for selection of project topics: an open-ended approach and a list of recommended project topics. In the open-ended approach, students are not assigned a specific project, but instead use the general project guidelines (see Figure 1) and an in-class discussion of the project concept as a starting point to determine a suitable topic and project scope.

Project guidelines intentionally provide little specific direction to the students in selecting their project, thus requiring students to take initiative to research topics. This approach has worked remarkably well at CSUS because typically over 80% of the students in the class work 20-40 hours per week for local engineering firms, where new design projects are always on-going and where new approaches and fresh ideas are emerging. Students begin by contacting engineers at their workplace to discuss ideas. They usually look for current or recently completed projects that appear interesting and involve application of structural concrete in design (including analysis), construction, materials, and/or research. Students are permitted and encouraged to use an actual project as a basis for their design project. For example, students may conduct an independent design review of part of a structure, design a simplified version of a structure, or use an actual project as a practical application for a topic such as high performance concrete, prestressed concrete, or reinforced concrete bridge design. Even where special topics are selected, teams are required to link their topic to a real-life project or other practical application.

Many students and employers have found this approach to be mutually beneficial. Students are motivated to explore the design process and end products at their company, including the purpose and objectives of a project, the design basis and approach, actual calculations, and plan sheets. Engineers are pleased to help student assistants become more knowledgeable about company design practice and are very willing to supply these students (whom they hope will become future full-time employees) with the necessary information and additional insight into the background and execution of a project. Indeed, many students have singled out this interaction as being one of the most beneficial parts of the design project.

Occasionally, team members will not have engineering jobs, practicing engineers with whom to interact, or appropriate projects at work. In such cases, students follow project guidelines that recommend students research a topic using one of many resources available for fresh ideas in structural concrete—magazines and other publications of organizations such as the American Concrete Institute (ACI), American Society of Civil Engineers (ASCE), Precast/Prestressed Concrete Institute (PCI), and the Portland Cement Association (PCA), as well as references found from myriad internet sources. The instructor may also recommend references and may occasionally help students obtain references.

A list of recommended project topics has also been used to help students select a project. This approach is not used exclusive of the previously mentioned approach; students may select a project using either approach. Although this approach limits student initiative in the selection process, it does not hinder students from taking “ownership” of projects because teams begin to participate in project activities more rapidly. One important advantage of providing a list of
topics is that the instructor can guide teams into projects that have already been demonstrated to be valuable learning experiences or that appear to be particularly promising. The instructor can also include topics with which students should be familiar, but are not covered in class due to time limitations. These projects often have a well-defined scope and suitable references.

Project Topics

During the first four semesters that the project has been implemented, student teams have selected thirty-six different projects using the two approaches. Table 1 lists these projects using four column headings including: topic, category, team size, and scope. Topics marked with an asterisk (*) are projects that teams selected from an instructor-provided list. The open-ended approach was used in the selection of all other projects. The second heading, designated CAT, refers to one of the following four categories: Design (D), Construction (C), Materials (M), and Research/Testing (RT). The third heading is the team size, and the last heading briefly identifies the project scope.

Table 1 shows that the vast majority of the projects (72%) have focused on design or design/construction. To develop a practical understanding of reinforced concrete, teams were encouraged to explore construction issues in their project when possible. Well over half of these projects involved both design and construction issues. About 20 percent of the projects addressed material issues, which in some cases were combined with design or testing objectives. The final 8% of the projects involved research and/or experimental testing conducted in the CSUS Structures Laboratory.

Projects have spanned an impressive gamut, including bridges, buildings, and many other interesting structures such as a deflection wall, storage basin, underground vault, residential slabs and foundations, and concrete homes. In addition, a number of projects addressed special topics that are generally applicable to a range of structures. Among these topics were seismic design and detailing, simplified design, prestressed concrete, structural floor systems, durability, and high performance concrete. Despite the general nature of these topics, teams were still required to link their topic to a practical application. Students also selected materials-related projects, including corrosion, concrete deterioration, and concrete repair. One project on high performance concrete involved strength and permeability testing of four different mixes with data analysis and application to bridge design. Teams have also participated in research projects with graduate students, and in two cases, teams conducted their own experiments to investigate the behavior of concrete beams. Because many students work for California Department of Transportation or other engineering firms involved in bridge design, it is not surprising that half of all the projects were bridge-related and that all four categories are included among the bridge projects. Sample slides for various projects are discussed in Section V.

Students were encouraged to work in 2-3 person teams to maximize student participation. Three quarters of the teams were in this size range. Occasionally, teams were permitted to include a fourth person. Only in extraordinary cases were students permitted to work alone. Two of the three research teams included six students. However, these were actually two three-person groups, which were necessary to cover the significant scope of the project. In these cases, both
groups worked together for the fabrication and/or testing aspects of the project, although each group bore separate responsibilities.

III. Project Proposal

By the end of the first month of the semester, teams are required to submit a project proposal. Figure 2 shows the nine items included in proposals. To help students select a suitable project and scope, teams are encouraged to meet with practicing engineers as well as the instructor to discuss the project prior to submitting the proposal. The instructor provides written feedback to the proposal within about a week. Although project proposals count only 10% of the report grade (no more than 1.5% of the course grade), teams have generally expended considerable effort in preparing proposals.

Advantages of requiring project proposals include: 1) ensuring teams are formed and functioning together early in the semester; 2) causing teams to carefully consider their project topic and objectives, and to develop a realistic scope based on tasks and a timeline; 3) enhancing student interaction with practicing engineers as well as the instructor; and 4) alerting the instructor to potential problems with project topics and/or scope; team coordination and functioning; and level of effort.

IV. Project Execution

After receiving feedback to the project proposal, teams use the next nine weeks to execute their project. During this time, teams conduct a wide assortment of activities, depending on the particular project. For example, projects focused on design, construction, and/or materials may involve review of plan sheets, design calculations, as well as other documentation that explains project constraints; acquisition and study of additional references; site visits; study of behavior and failure modes for structural systems and elements; review of design criteria and code provisions; and design calculations. Calculations are an important and practical factor to deepen the students’ understanding of structural concrete behavior and design, and thus are required. Teams perform calculations using computer applications as well as by hand. Teammates must check and initial calculations.

Research/testing projects that focus on experimental work in the laboratory involve a surprisingly large number of activities. For example, a recent beam testing project involved a study of background issues, specimen design including development of a spreadsheet, preparation of specimen drawings, development of an instrumentation plan, preparation of a materials list, acquisition of materials, installation of strain gages, fabrication of formwork and rebar cages, casting of concrete, preparation of test setup and data acquisition system, testing, and data analysis, including comparison of data to pretest predictions based on computer analyses.

Teams encounter many challenges in conducting project activities. They realize the usefulness of the project proposal as a guide but often find the need to deviate from it. Many find that the proposed scope must be reduced or that the project emphasis must be changed to address different issues than originally planned. Teams are instructed to justify the need for major
changes. Students often interact with practicing engineers and/or the instructor more than once during the course of the project to obtain additional information, ideas, and/or guidance. In addition, students learn to do their fair share of work, contribute to the team and work together to solve problems. Although students adopt certain roles for accountability, some students function spontaneously in undefined roles such as encouraging and helping others with their tasks or reconciling differences among teammates.

Teams submit a status report during Week 11, two-thirds of the way through the project execution stage. Teams report the actual status of the project, including any changes from the original proposal, and are encouraged to ask questions if additional guidance is needed. Status reports hold teams accountable and encourage them to make regular progress. They also alert the instructor to projects that may need adjustment for successful completion. Status reports also serve as the means for teams to indicate their preferred presentation date.

V. Project Presentations

The final week of class is reserved for in-class project presentations during which teams present the “crème de la crème” of their project results. Students gain valuable experience and knowledge through this process, which more than offsets the loss of two lectures. Presentations consist of a team oral presentation and project handouts. Presentation guidelines provide requirements for oral presentations and project handouts, as well as information regarding grading and tips for presentations. This section summarizes project presentations and also provides examples from actual student presentations.

Oral Presentations

Teams are required to summarize their project results and experiences in a MS PowerPoint presentation. For many students, the project presentation is one of their first formal presentations. Figure 3 shows an excerpt from the oral presentation guidelines. Teams are allotted five minutes per person, and teammates must speak approximately the same duration. Teams are strongly advised to spend adequate time to prepare quality presentations and are heavily penalized for exceeding the allotted time. Presentation guidelines have proven useful in providing adequate time for presentations and in helping ensure that all team members participate. To help teams achieve a high standard, students are also given a list of tips for presentations that match evaluation criteria.

Both the class and the instructor evaluate all presentations on a scale of 1 to 10 using a form developed at CSUS that addresses eight categories and criteria (see Figure 3). Each category is weighted equally, and the instructor’s score counts twice as much as the student average.

Although grading criteria are somewhat subjective, evaluations have generally been consistent and fair, perhaps because student evaluators are required to identify themselves on the evaluation forms. Grade inflation is not an issue; in fact, students tend to evaluate projects at least as strictly as the instructor in most categories. Students are also asked to write specific comments on the evaluation form to justify scoring. Students have expressed great interest in receiving this frank
feedback to their presentations. The instructor compiles comments and sends them to respective teams in “anonymous” form after presentations.

Presentation Handouts

Oral presentations must be accompanied by a class handout. Handouts provide classmates a clear synopsis of the project objectives and results, as well as a handy reference for potential future use. In addition, this requirement compels teams to clearly identify project objectives and results in preparation for their presentation and report. Figure 4 lists the four required sections of the handout. Students grade the handout during presentations, while the instructor grades it more closely at a later time.

Grading

During the past four semesters, the author has been greatly surprised by the motivation, time spent, and learning exhibited by students during projects. For this reason, the project weighting has increased from 15% of the course grade during the first semester to 25% during the fourth semester. Presentations count 40% of the project grade, and reports count 60%. Presentation grades are divided between the oral presentation and handout. The oral presentation counts 2/3 of the presentation grade. To emphasize the importance of the handout as well as the student experience in preparing it, handouts count 1/3 of the presentation grade.

Presentations are indirectly weighted in the course grade in another fashion. Teams are told that each student is a “lecturer” during the final week of class, and that students should pay close attention to presentations and take notes. The final exam then includes one or two “short answer” questions from the presentations. To help students focus on key aspects from the presentations and prepare for the final exam, the instructor emails the class a list of potential questions based on presentations. Exam questions are drawn from this list.

Sample Presentation Slides

Figure 5 shows representative slides from project presentations, including slides from each project category (design, construction, materials, and research/testing). These slides illustrate how students fulfill project requirements.

VI. Project Reports

The final product of the team project is a formal group report. In addition to providing teams the opportunity to improve written communication skills, project reports provide teams a more detailed and formal means to discuss project activities and results. Reports are due the final week of the semester. Report guidelines provide detailed requirements for report organization, as well as tips for report writing and report evaluation criteria.

Report Organization
To assist teams in structuring their group report, detailed guidelines are provided for report organization. Figure 6 shows the eight required sections of the report. Key aspects of the guidelines are discussed in class, such as recognizing the importance of each section of the report. For example, students are told that the main body of the report should include a presentation of the main project results using figures and tables. However, the main body should not include details of calculations, which are reserved for the appendix. Reports are limited to 14 pages for all parts of the report except the appendix, which has no length restriction. Both line spacing (1.5) and font size (11 point) are specified to ensure uniformity among teams. This length has generally been found to be adequate. Teams submit reports in 3-ring binders together with a CD that includes a copy of the presentation and report. Report guidelines also provide tips for teams, similar to approach used with presentation tips.

Grading

Reports count 60% of the project grade, which is 50% more than presentations. The larger weighting of the report emphasizes the importance of presenting project results effectively in written form. Report content counts 65% of the report grade and organization/presentation counts 35%. Guidelines provide a breakdown of points (100 points total) for the various sections of the report. For example, for the main body, the content and organization/presentation count 20 points and 17 points, respectively. However, the content and organization/presentation count 20 points and 5 points, respectively, for the appendix. This breakdown conveys to teams the relative importance of each section, and the need to address both content as well as organization and presentation. Specific criteria for evaluating the organization/presentation component include: grammar/syntax, controlling idea, organization of ideas, addressing the assignment, use of graphics, and attention to target audience.

VII. Team Grading

At the end of the semester after all project deliverables have been submitted, students confidentially grade their own participation and contribution to the project, as well as that of their teammates. Felder has suggested that this general approach is reliable. Using a scale of 1 to 10, students evaluate both their own and their teammates’ participation and contribution to the project. Students are also asked to discuss in some detail their overall team experience, dynamics among team members, and any challenges they encountered. In addition, students are encouraged to comment on ways to improve the project for future classes.

Project grades are modified based on student input and instructor observation. This is stressed at the beginning of the semester to encourage full student participation and to discourage, or if necessary to penalize, student “slackers”, who contribute little to the team project. When a one team member does not contribute, the other teammates are required to put forth extra effort and/or cannot complete the proposed project scope. With this grading scheme, students who contributed fairly are less likely to be penalized by a low team project grade. For example, if one student on a three-person team did little to contribute to the team but the other two teammates contributed fully, then an adjustment would be made to reflect the level of participation. If, based on teammate grading and faculty observation, an 80% contribution was determined for the
“slacking” student, then the overall project score would be multiplied by 0.80 for the student. The “20%” deducted from the student would then be shifted to the other teammates, whose score would be multiplied by 1.10. Adjustments have been necessary in less than half of the teams. Careful consideration of students evaluations and judgment must be exercised in modifying project grades, especially for two-person teams, as discussed in the next section.

VIII. Student Response

Students response to the team project, as expressed in written student comments, has been frank and helpful in making modifications to the project guidelines. On the one hand, students have generally been very positive, recognizing many advantages in participating in a team project. On the other hand, students have expressed frustration with various aspects of the project, particularly team work and the time-consuming nature of the project. Representative student comments (with minor editing) are summarized in Figure 7. Parts 1 and 2 of Figure 7 include student comments sent by email to the instructor after the final project report was submitted. These comments were part of student grading, as mentioned in the previous section. Comments included in Figure 7, Part 3, include student response to the question, “What was the most valuable part of the class to you?”, as well as unsolicited, confidential comments submitted as part of the course evaluation.

Figure 7 illustrates student perspectives on the many of the benefits of the project, such as:

- Relevance of course content: “It brought together the theoretical side with the real world side”
- Active learning: “The hands-on experience of designing, fabricating, and testing was an experience that I will never forget!”
- Practical learning: “I had never been on a concrete pour and I learned a lot about how things are done”; “What I learned in terms of construction and teamwork was more valuable than any theory this class could have taught.”
- Interaction with practicing engineers “who graciously donated their time” and “infected us with their enthusiasm”
- Development of teamwork skills: “I learned a lot about myself and my capabilities as a team leader and team member’
- Teamwork synergy: “Whatever one was weak in the other excelled, so together we made a very strong group”
- Insight into the design process: “I have a deeper understanding of concrete design and the design process itself”

Student comments also highlighted a number of problem areas as well:

- Large project scope: “I just barely skimmed the surface of a huge topic”
- Limited references: “This topic was really new and only limited materials were available”
- Perception of unfair advantage: “I feel that some students (who work for engineering and construction companies) have an advantage over people like me who does not understand what a girder is.”
- Open-ended nature of project: “The design project should be more defined and practical.”
• Required effort: “I think the project should be scaled down and prepared individually. A large project is a lot of work prior to finals.”

Many student comments centered on frustrations in teamwork, such as procrastination and lack of coordination or effort (Figure 7, Part 2). In addition, in three different two-person teams, teammate #1 reported that team coordination and teamwork were very good, while teammate #2 expressed an extreme dissatisfaction with teammate #1’s participation and provided detailed commentary to justify assigning a low grade to teammate #1. In cases of two-person teams, where an additional teammate is not available to corroborate the student comments, the author believes caution is necessary in adjusting grades. In two of the three cases mentioned above, the author agreed with teammate #2’s assessment. However, in the third case, the author felt that teammate #2 was overstating their case and thus a grade adjustment was not warranted.

IX. Challenges

Students and faculty members alike have faced numerous challenges in implementing the team project. Many of the initial challenges faced by students have been solved by the development of improved project guidelines. The guidelines shown in Figures 1-6 represent the latest edition of the project guidelines, which have been modified each semester for the past two years based on student comments as well as the instructor’s experience and observations. These guidelines will continue to be improved. Other challenges, such as those related to teamwork and project scope, are an inherent part of the project experience. Students learn to deal with these each semester, sometimes in consultation with the instructor.

Each semester the instructor faces challenges in implementing the team project, especially time-intensive activities related to developing project ideas, mentoring teams, and grading project reports. The author believes that students benefit the most if they have the option of selecting their own project as well as selecting from a list of projects. Developing a suitable list requires forethought and planning. For example, the most recent list of student projects (not included in Table 1) included nine projects, of which three involved fabrication and testing of concrete specimens, one involved construction documentation and calculations for a post-tensioned concrete parking structure currently being built on campus, and five related to design and/or materials issues involving the use of readily-available references and computer software. The experimental projects and on-campus construction project required considerable planning, coordination, and meetings prior to the start of the semester with graduate students, campus officials, contractors, and engineers. Although this preparation requires additional time, it helps ensure students have valuable project experiences. In addition, the instructor has found that many students will eagerly volunteer to participate in hands-on research projects for class credit alone.

Mentoring teams also requires a considerable commitment of time. The author has mentored an average of nine teams per semester at CSUS. Teams discuss their project with the instructor before they submit the project proposal, and usually each team makes an appointment to discuss their project one to two times after the proposal is submitted. In addition, experimental projects require visits to the laboratory and may require instructor participation to help obtain material donations. Some projects may also require meetings with practicing professionals. Clearly, extra
office hours are necessary for proper mentoring. Students, however, seem to profit from the interaction with the instructor and practicing professionals. The instructor also gets to know students much more closely, which enhances classroom teaching as well.

Finally, the instructor must grade project proposals, status reports, presentations and a final report. Grading the end-of-the-semester project report is a particularly time-intensive task and also requires that the instructor be abreast of technical issues and practices for many different topics. Staying abreast of current topics and practices is considered a benefit.

It is evident that implementing a team project requires more instructor commitment and time than a traditional design course. However, this approach to project-based education has generated significant student initiative, practical learning, and excitement. As outlined above, the instructor enjoys certain benefits as well. The author believes that the student and faculty benefits of implementing the team project exceed the “cost”.

X. Future work

Future work will include an assessment of student learning and fulfillment of ABET criteria in team projects.

Bibliography


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Table 1: List of Project Topics (Spring 2000-Fall 2001)
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<td>Cathodic Protection of Kings River Bridge</td>
<td>M</td>
<td>3</td>
<td>Study of materials and repair procedures</td>
</tr>
<tr>
<td>Durability and High Performance Concrete—Tehachapi Creek Overhead Bridge</td>
<td>M</td>
<td>3</td>
<td>Study of effects of concrete deterioration and admixtures, as well as construction cost</td>
</tr>
<tr>
<td>Carbon Shell System for Kings Stormwater Channel Bridge</td>
<td>M/D</td>
<td>2</td>
<td>Design using fiber reinforced plastic</td>
</tr>
<tr>
<td>Durability—Corrosion Effects and Life Cycle Costs*</td>
<td>M/D</td>
<td>2</td>
<td>Study of mechanisms of steel corrosion and concrete deterioration; prediction of life cycle costs using new software</td>
</tr>
<tr>
<td>High Performance Concrete</td>
<td>M/RT/D</td>
<td>4</td>
<td>Laboratory testing; data analysis; bridge girder design</td>
</tr>
<tr>
<td>Pullout Test Specimens for Precast Concrete Connections in Seismic Regions*</td>
<td>RT</td>
<td>6</td>
<td>Participation in current CSUS research; fabrication of specimens; independent study of anchorage issues</td>
</tr>
<tr>
<td>Design, Fabrication, and Testing of Reinforced Concrete Beams*</td>
<td>RT/D/C</td>
<td>3</td>
<td>Laboratory tests investigating behavior of four beams</td>
</tr>
<tr>
<td>Design, Fabrication, and Testing of Reinforced Concrete Beams*</td>
<td>RT/D/C</td>
<td>6</td>
<td>Laboratory tests investigating behavior of four beams; comparison of data and analytical predictions using software</td>
</tr>
</tbody>
</table>

*Project Selected from List
Abbreviations for Project Category (CAT):
D=Design; C=Construction; M=Materials; RT=Research/Testing

Table 1 (Cont.’): List of Project Topics (Spring 2000-Fall 2001)
The goal of the semester project is to study, summarize, and present a topic addressing a contemporary issue in structural concrete. This project has the potential to be a truly great learning experience. The project should:

1. Cause you to learn about a topic of interest beyond the scope of the course syllabus;
2. Have a practical, real-life application in one or more of the following 4 areas: design (including analysis), construction, materials, research;
3. Develop your ability to think, analyze and design at the structural system level, not only the component level;
4. Develop your ability to address both technical aspects, as well as other aspects that often constrain the project such as economics, constructability, durability, aesthetics, and other aspects which impact society at large;
5. Involve interaction with practicing engineers as much as possible;
6. Develop your ability to gather, evaluate, and synthesize information from various sources, to take new information and integrate it with past knowledge, and to investigate and challenge the way things are normally done;
7. Develop your understanding of the structural behavior/mechanics related to a structural concrete application;
8. Develop your ability to perform meaningful design calculations, by hand and computer;
9. Improve your written and oral communication skills;
10. Improve your teamwork skills, such as contributing a fair share of work, encouraging others to participate, cooperating with team members, sharing information, and helping reconcile differences among fellow team members;
11. Develop your ability to formulate and execute a plan, including specific tasks, to accomplish your project.

Figure 1: Project Guidelines Excerpt
Each team should discuss their project together and prepare a 2-page proposal for the instructor. The proposal should include the following sections:

1. **Title**—What is a succinct, yet meaningful title for your project?
2. **Participants and Roles**—Who are the team members? Who will be the designated “team leader” and what role(s) will each person play on the team?
3. **Summary of Topic**—What will you investigate? What specific issues will your project address? Summarize in 1-2 paragraphs your project concept, using two or more figures and/or sketches (these are required) to help describe it.
4. **Background Information**—Why is this a significant topic/project? Motivate the reader.
5. **Objectives**—What are the specific aims of your project? List several objectives.
6. **Tasks**—What tasks will be performed to achieve your objectives? Also list the student(s) primarily responsible for each task.
7. **Timeline**—How long do you expect each task to require and when will it be performed? Show this on a semester timeline.
8. **End Products**—What will be the final products of your project? In addition to the presentation and report, examples may include analyses, design calculations, drawings/sketches, documentation from other projects (plan sheets, calculations, photos, etc). Be sure to mention anything that will be placed in the appendix.
9. **References**—From where have you gathered your information? Use an acceptable format, such as that shown on the attached page.

Figure 2: Proposal Guidelines Excerpt
PowerPoint presentations of projects will take place in class during the last week of the semester. The total time for each team may not exceed: (5 minutes/person) x (number of persons). A “one-minute warning” will be given toward the end of your allotted time. Presentations that exceed this time limit will be penalized at the rate of 10% of presentation grade/extra minute (or part thereof). All team members are required to speak approximately the same duration (+/- one minute).

Presentations will be evaluated by the class and instructor in eight categories on a scale of 1 to 10: overall impression, preparation, organization, technical content, mannerisms, professionalism, style, and slides. The following criteria will be used as a basis for scoring: overall impression—how much impact the presentation has on the listener; preparation—how well rehearsed and fluid the presentation is, as well as if the presentation is within the time limit; organization—how clear and logical the flow is; technical content—how sound and appropriate the concepts appear; mannerisms—how appropriate eye contact, voice projection, and gestures are; professionalism—how appropriate dress and demeanor are; style—how clear and enthusiastic the presenters are; slides—how legible, clear, and attractive slides are. The instructor’s score will count twice as much as that of the class.

Adequate preparation is crucial to a successful presentation. Your in-class oral presentation should not be the first time you present your project! Students are strongly encouraged to practice individually and as a group. The flow of the presentation should be smooth, gradually “painting a picture” that delivers your main ideas. Have your teammates evaluate and constructively criticize the concepts and the overall flow of the presentation. This preparation will help you refine your presentation, ensure your presentation is effective and within the time limit, and give you much confidence.

Figure 3: Presentation Guidelines Excerpt—Oral Presentation

Project handouts should be passed out to each member of the class just prior to your presentation. These handouts should provide other students a synopsis of your project and will be a handy reference for possible future use. Handouts may be compiled from the written report, and should include the following:
1. Executive summary, including the main objectives and results of your project, as well as important lessons learned (page 1)
2. Tabulation of key results and charts (pages 2+)
3. Figures and/or photos illustrating your project and key concepts (pages 2+)
4. List of key references, in proper format (last page)

Unlike the executive summary in the formal report, this executive summary can refer to attached figures, tables, and other schematics. Handouts may not exceed five pages total, including all figures and references. Give the instructor your original handout as well as a copy. These handouts will be graded by the class and instructor.

Figure 4: Presentation Guidelines Excerpt—Presentation Handouts
An example format for the report is as follows:

1. **Cover Sheet**—Include a cover page with the university name, course title, project title, names of team members, instructor’s name, and date. Graphics are acceptable.

2. **Table of Contents**—Show the starting page number for each section in the report. Also identify the various sections of the appendix.

3. **Executive Summary**—Provide a one-page summary of the main objectives and key results, as well as important lessons learned through the project. Some results will likely be quantitative and can be included in a table if necessary. Unlike the executive summary handed out during the presentation, this summary should not reference figures, but should stand by itself.

4. **Introduction**—Include background information regarding the importance of your project (i.e., motivation) and the specific issues you are addressing. Clearly specify the project objectives.

5. **Main Body**—Include as many sections as necessary. “Main Body” is not a section title. Use this part of the report to discuss the main results of your project but do not giving “too many” details. Calculations should be placed in the appendix. But be sure to include plenty, repeat plenty, of figures (pictures, drawings, etc.) and tables within the main body to present your results and to help the reader follow your discussion. Large point deductions will be made when the discussion is not clear due to a lack of figures.

Any figures and tables that are discussed must be located within this part of the report and not in the appendix. Exceptions may be granted in special cases. “Extra” figures and tables may be placed in the appendix. Appropriate placement and labeling of figures and tables must also be used. The source of the figure or table must be included in parentheses if it came from a reference document. Material that is not your own should be referenced clearly within the text; otherwise this is plagiarism. Order references based on the order in which they appear in the report.

Figure 6: Report Guidelines Excerpt—Report Organization
6. **Summary and Conclusions**—Summarize what you accomplished through your project, the lessons learned, and what you can conclude based on your effort. Do not include new information in this section.

7. **References**—Properly identify key references used during your project, including practicing engineers and websites. Follow the rules attached to the Proposal Guidelines. References to professionals such as engineers should include the person’s full name, job title, company and branch office, address, as well as telephone number and/or email address.

8. **Appendix**—Include pertinent calculations, including analyses, independent design calculations, design calculations from an actual project, plan sheets, etc. All project reports must provide some type of supporting calculations and analyses in the appendix. Very limited computer output (several pages) is acceptable, but must be summarized or marked to indicate key values. Supporting calculations will weigh heavily in the content grade (20%). All calculations must be checked and initialed by a teammate (NOTE: an automatic 10% deduction will apply to calculations that are unchecked.) Calculations should provide the basis for important parts of your discussion in the main body. Key assumptions in the analysis and design should be mentioned in the main body of the report, not merely in the appendix.

Figure 6 (continued): Report Guidelines Excerpt—Report Organization
Relevance: Overall working on this project was an excellent learning experience on subject matter not directly covered in class. I feel it is important to continue these projects so that students can get a glimpse of real world practices.

Professional Contacts: I learned a lot about concrete and I got to connect with professionals in the field. I found this to be an exciting project although it was tremendously time consuming.

Professional Contacts and Relevance: During the research phase of this project, we communicated with engineers, in person, via phone, and email. All of the engineers we contacted graciously donated their time, providing us with several key technical reports and infected us with their enthusiasm. We are especially grateful to structural engineer xxx, whose guidance and insight simplified the key elements involved in a very complex project…Our out of pocket expenses was greater than xxx for the report. However, the insight gained from investigating a real civil engineering project with all of its constituent parts was priceless.

Site Visit: I did get a lot out of the site visit. I had never been on a concrete pour and I learned a lot about how things are done…I know any field work I can get will make me a better engineer.

Testing: I liked our subject a lot. I also like the testing and designing with test results. The project was a lot of work and long hours but I think it was a great experience. The hardest part was working around work and school for the testing that we did.

Perception of Unfair Advantage: I feel that some students (who work for engineering and construction companies) have an advantage over people like me who does not understand what a girder is. These students present to the class the type of work that they do and have been doing for 2-3 years. This makes it easier for them to put a presentation together since they are just presenting what they do at work.

Large Project Scope: In hindsight, I wish I would have tackled a tiny concept and really explored all of the avenues. As it was, I just barely skimmed the surface of a huge topic.

Limited References: I really like our topic because it’s interesting. However, some of the things in our topic were vague. One of the reasons was, this topic was really new and only limited materials were available. I think for the future, we have to consider the availability of the references.

Figure 7: Student Comments—Part 1
Teamwork Skills: The project got off to a slow start…there was no natural leader. Neither was anybody willing to take the role. As a result, not much was done in the earlier stages of the project. In addition, our initial topic selection was not a feasible topic for the project…However, despite these fallbacks, I would say that we worked well as a team once we found direction. This was quite different from other projects that I have worked on. Typically, a well defined goal is presented by the instructor and specific steps must be taken to reach that goal. I enjoyed the freedom to select the topic but found it difficult to actually select one. I think that this was a good experience and that it has prepared me for the Senior Design project. I learned a lot about myself and my capabilities as a team leader and a team member.

Team Success: I give everyone a 10. I generally despise group work, because the work distribution is almost always lopsided. Furthermore, team meetings are usually a waste of time. But, for this team, we communicated heavily by email, each of us pulled our own weight…It was probably the best team I’ve ever been on.

Team Success: We had an excellent group dynamic. Whatever one was weak in the other excelled in so together we made a very strong group.

Teammate Procrastination: The thing that bothered me about my teammates was the fact they both procrastinated at each step of the project. Calculations, PowerPoint presentation, and the report were all left until the last minute to be completed. This was very frustrating, not to mention stressful for me.

Lack of Coordination: I am extremely disappointed in the groups input and unwillingness to work together during this semester. One individual held onto all the resources for most of the time and claimed to still be unfinished in their part of the work. That person’s end result was the summarization of three pages out of the xxx book that related nothing to the project whatsoever. This held up the progress for the rest of the group. The ability to show up for meetings at an agreed time was far and few between if they showed up at all. This was evident during the presentations since no one showed up to practice.

Figure 7: Student Comments—Part 2
**Student Response to Question: “What was the most valuable part of the class to you?”**

The most valuable part of the class was the project. The hands-on experience of designing, fabricating, and testing was an experience that I will never forget!

Looking back, the project gave me the greatest feeling and sense of actually learning and doing something.

Working with students in groups and assisting one another, especially during the project.

The class project was very beneficial to my learning as it brought together the theoretical side with the real world side.

I learned so much with our project. It put into perspective a lot of class material.

**Anonymous Comments on Course Evaluation**

As a member of the beam analysis team, I was happy to have the experience in being involved in a major project, which helped the learning process. It took a lot of effort to make the project happen. I hope that the design, construction, analysis project can continue for other students in the future.

The learning experience that I had for the concrete beams will be valuable for actual engineering practice. I did not learn much about the theory of beams, but what I learned in terms of construction and team work was more valuable than any theory this class could have taught.

I think the project should be scaled down and prepared individually. A large project is a lot of work just prior to finals. Also not everybody in the group is dedicated and that increases the work load and stress for other members.

The design project should be more defined and practical. I think he should select a reinforced concrete project and walk the class through the design process.
An Independent Analysis of Little Brown’s Creek Bridge

Michelle Shupp  Troy Clemons  Stu Kapicka

Dead Loads:
- shape/size

Live Loads:
- H, Alt., P
- wind, EQ

Load Factors:
- γ, β, φ, I
- Final V & M

Final V & M

Selection and placement of reinforcement

Development Length

Deflections

Crack control

Stirrup sizes

Stirrup spacing

Comparison of Methods

Figure 5: Sample Team Presentation Slides
### Overview
- **Purpose**
- **Actual & Allowable Shear Forces**
- **Conclusion**

**Design Check**

<table>
<thead>
<tr>
<th>Design Check</th>
<th>Actual</th>
<th>Allowable</th>
<th>% Margin</th>
</tr>
</thead>
<tbody>
<tr>
<td>Long. Shear Friction ($V_L$)</td>
<td>1400 kips</td>
<td>4030 kips</td>
<td>287%</td>
</tr>
<tr>
<td>Trans. Shear Friction ($V_T$)</td>
<td>3700 kips</td>
<td>4668 kips</td>
<td>126%</td>
</tr>
<tr>
<td>Flexural (M)</td>
<td>66,600 kip-in</td>
<td>291,295 kip-in</td>
<td>437%</td>
</tr>
<tr>
<td>Direct Tension (Nc)</td>
<td>791 kips</td>
<td>4798 kips</td>
<td>606%</td>
</tr>
<tr>
<td>Bar Development Length</td>
<td>48 in</td>
<td>36.55 in</td>
<td>31%</td>
</tr>
</tbody>
</table>

*Figure 5: Sample Team Presentation Slides (cont.)*
Effects of Rust on Rebar in West Sacramento

40% W/C with Minimum Amount of Additives Added to the Black Steel

Figure 5: Sample Team Presentation Slides (cont.)
Member Design: Column

- 20% stronger than beams
- Close-spaced transverse reinforcement
- Core confinement = added strength

Building Forms and Rebar Cage

Figure 5: Sample Team Presentation Slides (cont.)
Test Setup

Third Point Loading

LVDT

Reihle Test Machine

![Test Setup Image](image-url)

**Figure 5**: Sample Team Presentation Slides (cont.)