

# **Collaborative Learning in a Design Course**

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## **Abstract**

This paper describes a method of collaborative learning used in a design course taught at the University of Louisville. Under the format used, time spent on traditional lecture is minimized and student participation, via team collaboration, is emphasized. Teams are required to prepare assigned homework problems and present solutions to them in class. The presentation, which is graded, includes a question and answer period.

## **Introduction**

The pedagogy described in this paper is used in a design course, CEE 422, Fundamentals of Steel Design. This pedagogy has evolved over the past four to five years. The motivation for the evolution arose from the author's desire to have the students participate actively in class and to make them more responsible for their own learning. In the author's opinion, traditional lecture format is not particularly effective in achieving either of these goals, at least not in a course such as CEE 422.

Accordingly, CEE 422 has evolved to the point where very little time is spent on lecture. This is possible because the subject of steel design is relatively mature, and there are numerous good textbooks and references upon which the student can rely to acquire basic requisite knowledge. This does not mean that there is not some benefit to in-class presentation intended to clarify or enhance understanding of text material, and some of this is done in CEE 422. However, it is the author's opinion that in an introductory course such as CEE 422, time is much more productively spent having students actively involved in the learning process.

## **CEE 422**

CEE 422, Fundamentals of Steel Design, is a course intended to introduce fourth-year civil engineering students at the University of Louisville to the AISC LRFD (AISC 1994) methodology for designing steel structures. This course includes the analysis and design of the general steel member types shown in Table 1. Assigned problems fall into one of the categories listed in the table.

Grading in CEE 422 is based on the student's performance in these areas: quizzes (40 %), assigned problems (35 %) and in-class presentations (25 %). More information may be found by going to the course web site at <http://www.louisville.edu/speed/civil/courses/taweig01/cee422-SteelDesign/>.

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Tension Members
Columns
Beams
Members under Combined
Forces
Connections
Column Base Plates

**Table 1 - General Classes of Problems in CEE 422**

### **Teams and Collaborative Learning**

Use and benefits of collaborative learning are well documented. Felder, Stice and Brent (Felder, Stice and Brent 2000) provide parameters for team organization, team policies, team roles, peer evaluation, collaborative activities, preparation of instructional objectives, and much more.

Other than the in-class quizzes, all work in CEE 422 is done on a team basis. The class is divided into teams consisting of three to four members, and each team member is assigned one of the following roles: coordinator, recorder, monitor and checker (Felder, Stice and Brent 2000). Roles are rotated four times during the semester so that each student assumes each role at least once. A method of peer evaluation (Felder, Stice and Brent 2000) is used to minimize "hitchhiking" (team members going along for the ride without carrying their share of the load).

### **Class Periods Involving Team Activity**

A typical 50-minute class period involving team activity in CEE 422 is organized as follows. The first five to ten minutes are spent taking a quiz related to the problem presented in the previous class. The next 15 to 20 minutes are spent having one of the teams present its solution to the problem assigned for that class. The next five to ten minutes are spent by the instructor on items such as providing general guidance for the next assigned problem, discussing organization of the LRFD Manual, or answering questions. Any time remaining in the period is spent on in-class team activity (for example, beginning the solution for the next problem). A few class periods in CEE 422 do not involve team activity. Such classes might include viewing a video, a slide presentation or discussing a particularly difficult topic in detail.

### **Problems, Grading and Presentations**

#### **Problems**

For most class periods, teams are assigned a problem to complete. Currently, each team problem has the same format, but the problems are individualized by assigning each team a different set of numbers. Figure 1 shows a typical problem and a full list of problems can be found on the course website.

There are currently 27 problems in the course library. The author has developed a suite of C++ programs that are responsible for generating all data, files and solutions necessary to manage the problem solving scheme. These programs do the following for a specific problem:

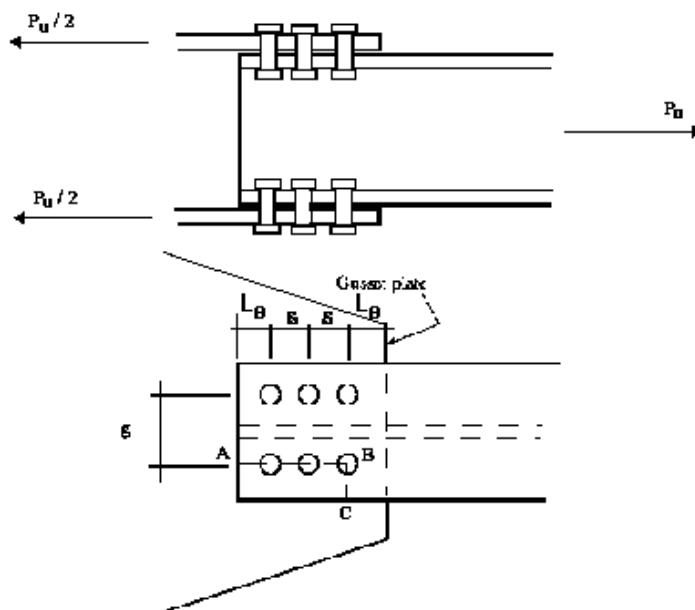
- 1) Generate "random" data for each team;

**CEE 422 Fundamentals of Steel Design**

**Spring 2001**  
**Homework Number 4**  
**TAS-0001 Tensile Capacity of a Wide-Flange Section**

Work this problem using your assigned numbers (see the table). A W section is connected at its ends with the gusset plates shown in the figure. Compute the tensile capacity of this section according to the LRFD specification. Be sure to include a block shear rupture check. You may assume that the gusset plate does not control the capacity of the connection. Use the values listed in the table next to your team name.

Team	Wide Flange	F <sub>y</sub>	g (in)	s (in)	L <sub>e</sub>	Bolt Diameter
A	W14x22	50	2-1/2	2	1-1/4	1
B	W27x102	50	5-1/2	2-1/4	1-1/4	1
C	W24x94	36	5-1/2	3	1-1/2	3/4
D	W16x31	36	2-1/2	2-3/4	1-1/2	7/8
E	W14x26	50	2-1/2	2	1	1
F	W14x99	42	5-1/2	2-1/4	1-1/2	1
G	W16x67	50	5-1/2	2	1-3/4	1-1/8



**Figure 1 - Typical Assigned Problem**

- 2) Generate an HTML file consisting of the problem statement and a table of data assignments for each team. An example of the HTML generated by the software is shown in Figure 1. This file is then transferred via FTP to the course website on the university server;
- 3) Generate a set of files containing solutions for each team. The appropriate file is eventually sent to each team along with the graded problem;
- 4) Generate a single file containing results for all teams in the class. This file is transferred via FTP to the university server and is used in conjunction with the online grading described in the section of this paper entitled "Grading".

This software and the online grading scheme are described in more detail in a companion paper under development by the author (Weigel 2001).

### **Grading**

Grading occurs in two phases. The first phase consists of teams submitting answers via an online grading scheme. The second phase occurs when the teams submit the hand calculations used to generate the answers for the online grading.

Teams are **required** to submit their answers via the online grader. In fact, the answers submitted online are the answers actually used to assign grades. The author still collects and evaluates the hand calculations. The purpose of doing so is to insure that the teams can provide documented justification for their results. Inadequate hand calculations, or hand calculations that do not support answer submitted online normally result in a penalty.

After the author assesses answers submitted online and the hand calculations, he returns a grade to the team via email. This email also has comments and explanation for point deductions. The author also attaches a file that contains a "correct" set of answers for that teams problem (see point 3 in the previous section entitled "Problems"). Hand calculations are also returned to the team, with appropriate comments, but without grades or any point deductions.

### **Online Grading**

The author has developed a method by which teams use the course website and submit answers problems online. Furthermore, the online grader has an option whereby teams can have their answers checked for accuracy without actually being submitted for grade. Teams normally use this option to correct errors and refine their answers until they are ready to submit them for grade.

The main advantage of this system is that it provides immediate feedback. Armed with information on which answers are correct and which are not, teams are motivated to work until all or most of their answers agree with the online grader. Because most of the answers submitted by the teams are correct, the grading load on the instructor is reduced.

While this online grading system is in its infant stages and needs much additional work, its implementation has significantly improved work submitted by the teams. In most cases now work submitted by the teams is correct, at least to the extent that their answers agree numerically with those answers expected by the online grader. While answers submitted online are correct in the sense that they agree with the "correct" answers, the author is not yet prepared to assert that the level of understanding of the course material has improved, which after all is the ultimate goal.

## **Presentations**

In class, one team is picked at random to present its solution. With roughly nine to ten teams, there are three cycles of presentations during the semester, with a team presenting only once during a cycle. Once a team has presented it will not be called upon to present again until a new cycle begins. The point in making random team selections is to insure, to the extent possible, that each team prepares each problem thoroughly, and not just those for which it presents. However, as the cycle progresses, team selection becomes more certain and previously unselected teams can better judge when they have to be prepared to present.

Presentations in CEE 422 are not intended to be formal in the sense that slides, elaborate figures or intricate coordination on part of the presenting team is required. Preparation for the presentation should require no more than solving the problem and fully understanding the steps involved in obtaining a solution.

Teams are told that the presentation should be generally organized as follows:

- 1) Describe the problem to be solved;
- 2) Present and describe any figures related to the solution;
- 3) State the LRFD provisions relevant to the problem;
- 4) Describe the solution strategy in general terms;
- 5) Present the specific solution for the problem
- 6) Field questions posed by classmates and / or instructor.

Teams may select a single individual to present the problem, or multiple team members may present. In either case, all team members are responsible for answering questions.

## ***Instructional Objectives***

For each problem, the author has developed a detailed set of instructional objectives based on Bloom's Taxonomy (Bloom and Krathwohl 1984). Students are told that any questions posed by the instructor will be based on the instructional objectives and that, for purposes of their presentation (and the quizzes), they are responsible for mastering the instructional objectives. Further, instructional objectives are cumulative in that once a problem is covered, students are responsible for those objectives for any subsequent problem. A typical set of instructional objectives is shown in Table 2.

## ***Presentation Grades***

A team is given a collective grade for the presentation. Individual presentation grades are adjusted according to peer evaluations and individual responses to questions. Each team member is questioned during the presentation to determine his or her individual level of knowledge of the problem. Depending on the response, points may be deducted against the individual's presentation grade. In addition, the team may also be penalized. The point here is to invest each team member in level of knowledge of his or her teammates (this is one of the goals of collaborative learning). However, the team penalty is typically much smaller than the individual penalty. For example, if the individual is penalized 10% for failing to answer a question correctly, the team may be penalized only 2%.

## **ABET**

In addition to offering some new pedagogy for a design course, the method used in CEE 422 addresses several issues important to ABET. In particular, it addresses, at least partially, the following ABET assessment areas;

- the ability to function on teams;
- the ability to communicate effectively.

### **For Problem TAS-001 the student should be able to:**

- List the LRFD limit states applicable to a wide-flange section used as a tension member
- Calculate the capacity of a wide-flange section according to the yield limit state
- Calculate the net area of a wide-flange section for use with the fracture limit state
- Calculate the effective net area of a wide-flange section for use with the fracture limit state
- Explain the concept of effective net area and why its use is necessary in the design of tension members
- Calculate the capacity of a wide-flange section according to the fracture limit state
- Calculate the capacity of a wide-flange section according to the block shear limit state
- Determine the tensile capacity of the wide-flange section used in this problem

**Table 2 - Typical Instructional Objectives**

CEE 422 obviously also addresses more traditional issues such as the ability to apply knowledge of math, science and engineering and the ability to design components of systems, but there is nothing in the proposed pedagogy that changes the manner in which these issues are addressed.

## **Pedagogy Evaluation**

Student feedback on CEE 422 has been positive. They prefer the daily quizzes to periodic tests and most feel that presentations are an effective teaching method. In particular, online grading, with immediate feedback, is flagged by the students as being very helpful. There have been several students who have made it a point to tell the author that they enjoyed the class and felt that they learned a lot.

The chief complaint deals with lack of lecture time to address new topics. However, the author feels strongly that this method, even though not popular, is effective in forcing students to read the text material and become familiar with the information in the LRFD manual. Without this approach, there were always a number of students who tried to make it through the course with only minimal exposure to assigned reading material. Also, there are always a few students who are uncomfortable making an oral presentation.

Because only one section of CEE 422 is taught, it is not possible to study the effectiveness of this pedagogical approach with one more based on traditional lecture arrangement. An indirect measure might be available through the design portion of the FE exam. The author plans to investigate whether results from the FE exam might be helpful in assessing the effectiveness of the approach being used in CEE 422.

## **Proposed Enhancements**

There are many areas in which the methodology used in CEE 422 needs improvement. Some of these are listed here:

- 1) The author sees the chief problem with the current methodology used in CEE 422 is that it does not deal effectively with the fact that design course, by nature, involve open-ended problems. As structured now, the methodology is more suited to an analysis course rather than design course. This is a major problem that the author intends to address in the near future;
- 2) The number of problems in the course library must be increased. Currently, each team works the same problem, but each team uses different data. The author intends to expand the library of problems to the point where each team has a different problem;
- 3) Certain topic areas (such as connections) need to have problems added to the library;
- 4) The author is also considering giving teams advance notice of when they will be required to present solution to an assigned problem;
- 5) Increased reliance on the online grader. The author intends to create an online help system that would be available with each problem. When a team encounters difficulty with a problem, the online help system might be able to provide guidance.

## **Summary**

As has been mentioned, there are several significant issues yet to be addressed, but the author believes the methodology used in CEE 422 is novel and effective. Many of these issues require only time and effort to correct, but others require careful thought and planning. With each semester that the course is taught the author enhances the pedagogy, as time permits. Sometime in the not too distant future some type of quantitative study must be done that will reveal whether or not the methodology produces better designers of steel structures.

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