

# Teaching Behavior or Teaching Theory in Design Courses

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## Abstract

Some of the courses in structural engineering, especially, design courses contain a large amount of theory, equations, charts, and specifications. As educators, we feel sometimes that students are not enjoying the course to the level desired. However, we feel that this is the proper way to teach the course therefore we should not alter our teaching style. It may be more interesting for students if they are exposed to some sort of virtual lab that teaches them the behavior rather than the theory of structures. Some of instructors think that a student can understand how to do design if the read about in the textbook. But, understanding the behavior is more important. It is debatable whether we should follow a pure behavior approach or a pure theory and design approach. It may be worthwhile to attempt to incorporate both approaches in our design courses, however, time may be a challenge. One among many courses of this nature is the Structural Steel Design Course. This course is offered in structural engineering, architecture, construction management, and architectural engineering programs in general. This course is theory intensive and basically there is so much to do within a limited time. This paper presents an effort preformed in the Civil Engineering Department at Ohio Northern University to teach the Structural Steel Design course effectively. The course is a required course for senior civil engineering major students. A virtual laboratory was integrated into the course to equip students with understanding of behavior and instability of steel members. MASTAN2 software package was used. The laboratory assignments covered most of topics taught in the course. The laboratory did not only stress on the importance of understanding instability aspects of steel members but also on understanding concepts behind information in the steel construction manual. The laboratory gives students opportunity to observe how changing parameters can affect stability of the members and also provides opportunity to conduct comparisons with the steel construction manual. This laboratory was designed in an effort to equip future engineers with experience and understanding of behavior and design of steel structures.

## Introduction

It is important to equip all graduating engineers with the necessary design skills through teaching the engineering design courses, effectively. The Structural Steel Design course, similar to other engineering design courses, contains a large number of topics. It includes design of tension member, compression member, beam, beam-column, and simple connections. Presenting only the AISC steel construction manual design methods and equations may not be attractive to the students. The course can be significantly enhanced through teaching the behavior and instability of steel members as well. It is always challenging to incorporate both components in one course. It may sound like teaching an engineering design course is challenging therefore it may require a suitable strategy to effectively teach it.

There are many papers published that addressed ways to teach an engineering design. It is claimed that design is behavior therefore behavior shall be taught [1]. The design is important thus professors must teach engineering design in the most effective way. It was recommended to design the engineering course to have learning activities outside and inside the class room since such strategy was proven to improve the course [2]. The design of an interactive course to assist students to learn outside of the class room may improve the learning experience. There are many elements available that can be used such as study groups, student/teacher conferences, problem solving sessions, software labs, and additional homework and reading assignments. This facilitates adding various learning approaches in the engineering courses, which will in turn enrich them [2]. From a study [3], a senior student spent a considerable amount of time to define the problem of a project, gather information, and develop design ideas in addition to doing the design. A comparison presented in the aforementioned study showed that a balanced process between doing the required preparation to undertake the design, which requires a full understanding of behavior and doing the design, leads to a higher quality design [3].

Using the software in this course permit fulfilling ABET outcome-K “an ability to use techniques, skills, and modern engineering tools necessary for engineering practice”. Typically, in steel design course, there is so much to do in so little time. As educators, we may want to think about an active learning way to teach an engineering design course. There is a long history of developing a virtual laboratory to teach behavior of steel structures. In early 2000, educational software MASTAN2 was developed and it was coupled with textbook. It is Matlab-based and available on all platforms. Also, it includes suite of nonlinear analysis options. It is easy to use, however, some prior knowledge is needed for successful use of the software. MASTAN2 is a standalone and available on PC and Mac. It is available at no cost over the web ([www.mastan2.com](http://www.mastan2.com)).

## **Using Virtual Lab**

The Steel Design course is a required course and is usually offered every year in the Fall semester. In this year, the virtual lab was first introduced. The lab assignments were designed to achieve the following learning objectives,

1. Data Analysis: show the ability to analyze and interpret results. Show also ability to write and support conclusions.
2. Learn from failure: be able to discover if results do not make sense hence adjustments need to be done
3. Teamwork: ability to work in teams and coordinate with other team members to finish the work in a timely manner. Be able to divide the work on all the group members and put all the pieces together to form the final product.
4. Ethics in the lab: deal with integrity. Understand that you can consult with other groups, but you can not copy their work.

In the lab, a number of assignments were given. A tutorial showing a step by step procedure to accomplish the lab was given to the students for all of the lab assignments. Also, for some of the lab assignments, students were asked to respond to ‘what if’ scenarios types of questions. Also,

in some cases, they had to conduct a parametric study to respond to these sort of questions. The lab assignments were designed to cover the following topics:

- Elastic Column Buckling and the effect of end restraint
- Effective Length K factors for Frame Members

In order to assess the effectiveness of teaching the behavior of steel member using the virtual lab in combination with a structural analysis software package used in the Steel Design course and to measure the level of impact on the student learning, a survey was conducted in class. After the completion of the course, students were given a survey to measure the effectiveness of using a virtual lab in the Steel Design course. Figure 1 presents the survey form that was distributed to the students. The class had Twenty (20) senior civil engineering major students and all of them participated in the survey. The survey contained ten (10) questions to be rated on a scale from 0 to 5; 0 is the lowest and 5 is the highest. The authors desired to determine how students felt about the course after using the software in the Steel Design course.

## **Course Learning Outcomes**

The Steel Design course is designed to enable students to (1) understand the Load and Resistance Factor Design (LRFD) concept and ability to use AISC-Steel Manual, (2) Analyze and design tension members, (3) Analyze and design compression members, (4) Apply the concepts of elastic behavior, yielding, fracture and buckling in design and analysis of steel members. This outcome is basically the limit states that you used mostly to design tension and compression members, beams, beam-columns, and connections, (5) Analyze and design members in flexure (design of beams), (6) Analyze and design members subjected to combination of axial and bending (design of beam-columns), and (7) Analyze and design simple connections. The course outcomes were rated on a scale from 1. Strongly disagree to 5. Strongly agree. The ratings received this year for the 1-7 outcomes listed above were 4.7, 4.6, 4.6, 4.0, 4.3, 3.9, and 3.7, respectively. In the previous year, at which the virtual lab was not yet integrated, in the course, the ratings received were as follows 4.5, 4.2, 4.1, 4.0, 4.1, 3.8, and 3.4 for the seven outcomes, respectively. It can be observed that students learning have improved as per the numerical values, which can be owing to the use of the software as well.

The year before, at which the software was not implemented in the course, the class grade distribution was 19.23% A, 65.39% B, 15.39% C, 0% D, and 0% F. for a class size of 22 students. This year, after implementing the use of the software, the class grade distribution was 35% A, 60% B, 5% C, 0% D, and 0% F for a class size of 20 students. A slight improvement was observed in students performance after the software was included in the course. Student performed slightly better in homework assignments, midterm exams, projects, and final exam.

## MASTAN2 software

Provide ratings in response to the following questions (**1 is the lowest and 5 is the highest**)

1. I feel that a student can learn Steel Design depending solely on the lectures without the need for any software package to teach them the behavior of steel structures.

1                       2                       3                       4                       5

2. I feel that the use of a software like MASTAN2 to provide an opportunity to learn about the behavior of steel structures is needed in Steel Design course.

1                       2                       3                       4                       5

3. The combination of using Structural Analysis software package and MASTAN2 is a good combination in Steel Design course.

1                       2                       3                       4                       5

4. The MASTAN2 software enhanced my learning in the Steel Design course.

1                       2                       3                       4                       5

5. The lab assignments using MASTAN2 software were related to the materials covered in class.

1                       2                       3                       4                       5

6. The MASTAN2 software was user-friendly.

1                       2                       3                       4                       5

7. The tutorial and directions provided were well detailed which helped me to accomplish the assigned lab.

1                       2                       3                       4                       5

8. It is a good idea to assign a number of lab assignments using MASTAN2 without providing any tutorials to test the level of understanding of the software.

1                       2                       3                       4                       5

9. If I were to retake the Steel Design course, I would like to have more lab assignments using MASTAN2.

1                       2                       3                       4                       5

10. If I were to rank this lab among other labs that I have taken, I would rank it among the best

1                       2                       3                       4                       5

**Figure 1. Survey Form**

## Results of Survey

After students feedback was received, data was collected, analyzed, and then discussed. A pie-chart for the response to each question was generated (Figure 2). The results of the survey will be used to improve the lab experience in the future and hence the effectiveness of the lab is expected to increase. Also, the feedback will also help to improve the lab when the course is taught next time. In what follows, a discussion for the response to each question is presented and a set of conclusions will be presented in the next section.

**Question # 1:** *I feel that a student can learn Steel Design depending solely on the lectures without the need for any software package to teach them the behavior of steel structures.*

About 50% of students participated in the survey gave ratings above 4. These results shows that 50% of the students enrolled in the course think that they can learn the design without learning the behavior.

**Question # 2:** *I feel that the use of a software like MASTAN2 to provide an opportunity to learn about the behavior of steel structures is needed in Steel Design course.*

About 90% of students participated in the survey gave ratings above 3. These results highlighted the importance of having a software like MASTAN2 in the Steel Design course. It was important to establish the importance of using a virtual lab in the course.

**Question # 3:** *The combination of using Structural Analysis software package and MASTAN2 is a good combination in Steel Design course.*

About 100% of students participated in the survey gave ratings above 3 for this question. It seems that the majority of the students think that the use of Structural Analysis software and MASTAN2 make a good combination. Therefore, both of them will be employed in the future.

**Question # 4:** *The MASTAN2 software enhanced my learning in the Steel Design course.*

About 60% of students participated in the survey gave ratings above 3 for this question. The Majority of students believe that MASTAN2 was important in their learning. Further enhancements may be necessary to increase the number of students satisfied with the software package.

**Question # 5:** *The lab assignments using MASTAN2 software were related to the materials covered in class.*

About 90% of students participated in the survey gave ratings above 3. Students believe that the software assignments were on the topics discussed in class therefore it can further enhance the students learning of the course. Some students do not strongly think that the assignments were related to the materials covered in class, however, the percent of this group is small.

**Question # 6:** *The MASTAN2 software was user-friendly.*

Looking at results of the survey, only 70% of the students participated in the survey think that the software was user-friendly. This is the majority of the students. The use of the software is not very simple since either a prior knowledge or step-by-step guidelines is needed to use the software. To make it easier to use the software, detailed tutorials were developed and handed out to the students for each lab.

**Question # 7:** *The tutorial and directions provided were well detailed which helped me to accomplish the assigned lab.*

Approximately, 60% of the students participated in the survey think that the tutorials given to assist them to do the lab assignments were helpful. The average rating for this question is about 2.7. Although the majority of the students benefited from having the tutorials, others do not agree

to the same level. This may be attributed to the complexity of the software as well as not having a prior knowledge of the software.

**Question # 8:** *It is a good idea to assign a number of lab assignments using MASTAN2 without providing any tutorials to test the level of understanding of the software.*

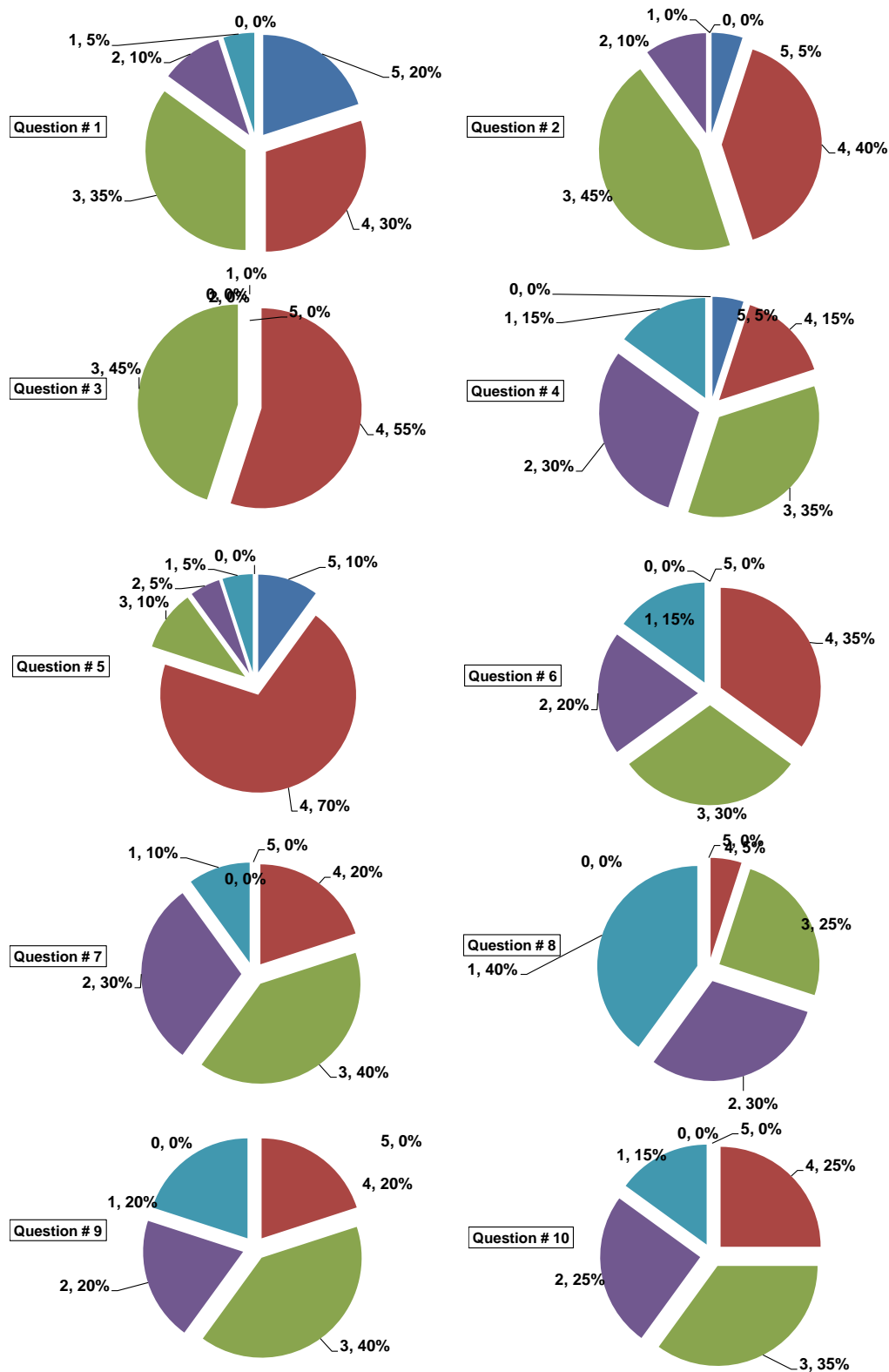
About 30% of students participated in this survey gave ratings above 3 for this question. Therefore, students think that tutorials shall be provided with all lab assignments. The instructor thinks that assigning labs without tutorials is a good way to test student familiarity and knowledge of the software. To take students opinion into account, tutorials will be provided for a large number of lab assignments while they will not be available for labs similar to those completed by students using a tutorial.

**Question # 9:** *If I were to retake the Steel Design course, I would like to have more lab assignments using MASTAN2.*

Approximately, 60% of the students participated in the survey think that assigning more labs using MASTAN2 will be helpful. Next time the course offered, more lab assignments using MASTAN2 will be given.

**Question # 10:** *If I were to rank this lab among other labs that I have taken, I would rank it among the best.*

Students responded differently to this question. About 20% of students judged that lab is the best lab of labs taken in different courses. Another 20% of students think that this lab is among the best two labs. About 40% of students think that it is among the best three. The other 20% of students think that the lab is among the best four. The average ratings for this question is about 2.7. On average, this lab can be considered among the best three labs of courses that students took.



**Figure 2. Detailed Results of Survey**

## Conclusions

A survey was conducted to evaluate the student experience of having a virtual lab integrated in the Steel Design course. Using MASTAN2 may provide them with an opportunity to understand the behavior and instability of steel members. Results of this survey are found to be important and will be used to improve students experience when the Steel Design course is taught next time. From the conducted study, the following conclusions are drawn:

- 1- Incorporating a virtual lab in the Steel Design course is found beneficial and students found it rewarding. Graduating engineers need to understand both of behavior and design of steel members, therefore it is necessary to include both components in the Steel Design course.
- 2- The combination of using Structural Analysis software package and MASTAN2 sounds attractive. The instructor will continue to utilize both of them in the Steel Design course.
- 3- When the course is taught next time, more lab assignments using MASTAN2 will be given. The lab assignments will cover all of the topics discussed in the Steel Design course.
- 4- Providing tutorials to help students to accomplish the lab assignments is important and students consider it helpful. It seems that most of students prefer to be provided with tutorials, however, not providing tutorials sometimes is needed in order to measure students familiarity with the software. Nonetheless, this may be done after students are familiar with the software to a reasonable extend.

## References

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